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PHRENICECTOMY IN THE TREATMENT OF PULMONARY DISEASES

AN ANALYSIS OF SIXTY-THREE CASES *

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While much has been written about phrenicectomy, few reporters have evaluated the results of the operation in a large series of cases. This article, in which the late results of phrenicectomy performed by the surgical staff of the University Hospital for various pulmonary diseases are considered, is presented as a contribution toward a better appreciation of the indications for the procedure.

HISTORY

In 1911, Stuertz [1] first suggested paralyzing half the diaphragm by division of the phrenic nerve in the base of the neck, in order to relax a diseased lower lobe which could not be compressed by artificial pneumothorax. He believed that it was especially indicated in basal bronchiectasis and tuberculosis. Sauerbruch,[2] in 1913, reported five cases in which he had performed phrenicotomy.

In the next few years the operation was performed by other European surgeons for a variety of pulmonary lesions. Walther,[3] in 1914, showed that simple phrenicotomy did not completely paralyze the diaphragm in more than 50 per cent of cases and that in 20 per cent of the cases normal function returned.

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* From the Department of Surgery, University Hospital, the University of Michigan Medical School.

* Thesis submitted to the Faculty of Surgery of the Graduate School of Medicine of the University of Pennsylvania in partial fulfilment of the requirements for the degree of Master of Medical Science for graduate work in surgery.

1. Stuertz: Künstliche Zwerchfellähmung bei schweren chronischen einseitigen Lungenerkrankungen, Deutsche med. Wchnschr. **37**:2224, 1911.

2. Sauerbruch, F.: Die Beeinflüssung von Lungenerkrankungen durch künstlicher Lähmung des Zwerchfelles (Phrenikotomie), München.med.Wchnschr. **60**:625, 1913.

3. Walther, H. E.: Röntgenologische Untersuchungen über die Wirkung der Phrenikotomie, Beitr. z. klin. Chir. **90**:358, 1914.

Goetze [4] and Felix [5] showed that from 20 to 80 per cent of persons have one or more accessory phrenic nerves and that the suprapleural sympathetic plexus sends motor fibers to the diaphragm through the phrenic nerve. In order to insure complete paralysis of half of the diaphragm, Goetze [4] proposed his radical phrenicectomy in which he exposed the phrenic nerve, freed it from connecting sympathetic fibers, resected 1 cm. or more, exposed the nerve to the subclavius, which nearly always contains the accessory phrenic fibers when present, and resected 2 cm. of it. Felix [6] proposed evulsion or exeresis of the nerve for a distance that would insure breaking its connection with the suprapleural plexus and all accessory nerves.

The work of Felix and Goetze served to popularize the operation on the continent. The excellent monograph of John Alexander,[7] "The Surgery of Pulmonary Tuberculosis," popularized the operation in America.

ANATOMIC AND PHYSIOLOGIC EFFECTS OF PHRENICECTOMY

Interruption of the phrenic and accessory phrenic nerves causes an immediate paralysis and subsequent atrophy of the corresponding half of the diaphragm, which remains in the position of expiration and rises still higher as atrophy progresses. It may rise from 1 to 10 cm. on the right and from 1 to 8 on the left side, the maximum rise often occurring weeks or months later. During normal inspiration it may descend slightly because of the tug exerted directly by the unparalyzed side. In forced respiration or on sniffing, the paralyzed side moves paradoxically.

After exeresis or radical phrenicectomy the muscle does not regenerate, although Zadek and Sonnenfeld [8] reported one case of return of normal function eighteen months after exeresis. In one of our own cases an evulsion of 10 cm. of the left phrenic nerve and a resection of 1 cm. of the nerve to the subclavius were done. Immediately after operation and two months later there were definite paralysis and paradoxic movement of the left side of the diaphragm as shown by the fluoroscope.

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4. Goetze, Otto: Die radicale Phrenikotomie als selbständiger therapeutischer Eingriff bei der chirurgischen Lungentuberkulose, Arch. f. klin. Chir. **121**:244, 1922; Die radicale Phrenikotomie als selbständiger therapeutischer Eingriff bei einseiger Lunger-phthisis, Klin. Wchnschr. **1**:1496, 1922.

5. Felix, Willy: Anatomische, experimentelle und klinisch Untersuchungen über den Phrenikus und über die Zwerchfellinervation, Deutsche Ztschr. f. Chir. **171**:283, 1922; Untersuchungen über den Spannungszustand und die Bewegung der gelähmten Zwerchfelles, Ztschr. f. d. ges. exper. med. **33**:458, 1923.

6. Felix (footnote 5, first reference).

7. Alexander, John: Surgery of Pulmonary Tuberculosis, Philadelphia, Lea & Febiger, 1925, vol. 15, p. 175.

8. Zadek, quoted by Sonnenfeld, Arthur: Klinisch Beiträge zum Wirkungsmechanismus der isolierten Phrenikus Exhairese, Beitr. z. Klin. d. Tuberk. **69**:340, 1928.

Nine months later fluoroscopic examination showed paradoxic movement of the left side of the diaphragm on sniffing, but on forced inspiration an excursion of 3 cm. of normal motion, the left side of the diaphragm lagging behind the right.

The rise of the diaphragm decreases the capacity of the lung from one-fourth to one-third (Gercelez [9]), or from 400 to 800 cc. (Brunner [10]). It partially compresses and relaxes the lung and abolishes the tug of the diaphragm on the diseased lung. As a rule, the rise of the diaphragm interferes in no way with respiration nor does it produce dyspnea. Lemon [11] has shown this by his experiments on dogs. Dünner, Lasar and Mecklenburg [12] reported the case of a child who had a bilateral phrenico-exeresis done without respiratory difficulty. It usually makes cough and expectoration easier, though sometimes the reverse is true.

RATIONALE OF THE PROCEDURE

The therapeutic ideal in the treatment for pulmonary diseases is rest. Surgically, it is best obtained by: (1) artificial pneumothorax, (2) thoracoplasty, (3) multiple intercostal neurectomy plus phrenicectomy and (4) phrenicectomy, in the order named. The latter only partially rests and compresses the diseased lung, and because of this incompleteness it cannot take the place of the other three methods. However, the added rest and compression given by paralysis of the hemidiaphragm are often enough to influence markedly the pathologic condition.

Most observers ascribe the beneficial effects of hemidiaphragmatic paralysis to the partial rest, relaxation and compression of the diseased lung thus produced and to the diminution of the amount of toxins pumped into the circulation. Dünner, Lasar and Mecklenburg [13] denied that any compression or rest of the lung occurs and expressed the belief that interference with the vagus and sympathetic fibers to the lung during evulsion of the nerve explains the effect. Sergent and Baumgartner [14] expressed the belief that the effect of phrenicectomy is

9. Gercelez, quoted by Sonnenfeld: Beitr. z. Klin. d. Tuberk. **69**:340, 1928.

10. Brunner, A.: Die Prognosis bei der operationen Behandlung der Lungentuberkulose, Arch. f. klin. Chir. **121**:482, 1922.

11. Lemon, W. S.: The Physiologic Effect of Phrenic Neurectomy, Arch. Surg. **14**:345 (Jan.) 1927.

12. Dünner; Lasar, and Mecklenburg, Max: Zum workingsmechanismus der Phrenikus Exhairese, Ztschr. f. Tuberk. **46**:406, 1926.

13. Dünner and Lasar: Zur Frage der Phrenikus Exhairese, Ztschr. f. Tuberk. **49**:31, 1926. Dünner and Mecklenburg: Der Einfluss der Phrenikus Exhairese auf die Atmung, Deutsche med. Wchnschr. **52**:1819 (Oct.) 1926. Footnote 12.

14. Sergent, E., and Baumgartner, R.: A propos de huit cas de phrenicectomie, Bull. et mém. Soc. méd. d. hôp. de Paris **42**:20 (Jan.) 1926.

limited to the lower lobe. Fournet [15] and Orsos [16] claimed that the effect on the apex of the lung is as great as on the middle and lower lobes in that the diaphragm exercises an equal pull on any part of the lung where there is a counter pull. Jessen [17] did not believe that this is true when the upper lobe is fixed by fibrosis and adhesions to the wall of the chest, in which cases the effect of phrenicectomy is limited to the sound stretchable lower lobe. Dumarest and Bérard [18] expressed the opinion that only tuberculous lesions which show a tendency to fibrosis and spontaneous contractility are influenced by phrenicectomy, and that it matters not in which part of the lung the lesion is situated; if it possesses a capacity for spontaneous retraction, one may expect benefit from phrenicectomy.

It is true that while lesions of the lower lobe are on the whole more favorably affected, many patients with lesions of the upper lobe have been reported as cured by paralyzing the diaphragm.

INDICATIONS

Because phrenicectomy produces only partial rest and relaxation of a diseased lung, paralysis of the hemidiaphragm must be considered mostly as a complement to other methods of treatment and other surgical procedures. It must be considered, however, as an independent procedure in a growing number of situations.

A. Its greatest usefulness is in the treatment for pulmonary tuberculosis which is mainly unilateral, and here its most frequent indication is as a complementary procedure to:

1. Extrapleural thoracoplasty: (*a*) to cause sufficient improvement in a very ill patient so as to make thoracoplasty a safe undertaking; (*b*) to test the better lung and to see if suspicious lesions are active or not, or if quiescent to determine if they will stand further compression of the badly diseased side; (*c*) to increase the amount of compression gained by thoracoplasty, and (*d*) as a complement to a partial thoracoplasty.

2. Schede thoracoplasty: to decrease the size of a tuberculous empyema preliminary to closure of such cavity by thoracoplasty.

3. Artificial pneumothorax: (*a*) when pneumothorax is not producing satisfactory results because of incomplete collapse usually due to basal or lateral adhesions between the lung and wall of the chest; when basal adhesions are causing pain, or when the lung is expanding under a pleural effusion; (*b*) when pneumothorax is satisfactory, in

15. Fournet, quoted by Jessen, Harold: Beitr. z. Klin. d. Tuberk. **64**:613 (Oct.) 1926.

16. Orsos, quoted by Pigger, H.: Phreniko-exhairese bei döppelseitiger Lungentuberkulose, Beitr. z. Klin. d. Tuberk. **65**:262 (Dec.) 1926.

17. Jessen, Harold: Zur Frage der künstlichen Zwerchfellähmung, Beitr. z. Klin. d. Tuberk. **64**:613 (Oct.) 1926.

18. Dumarest, F., and Bérard, L.: Les resultâts de la phrenicectomie dans le traitement de la tuberkulose pulmonaire, Rev. de la tuberc. **9**:161 (April) 1928.

order to lessen the number of refills, or to lessen the incidence or amount of pleural effusion; (*c*) to diminish the size of the hemithorax when pneumothorax is stopped in order that the thorax may fit the size of the newly expanded but shrunken lung, and (*d*) to take the place of the pneumothorax when for social or economic reasons it must be discontinued.

Weise [19] claimed that in children phrenicectomy makes pneumothorax less effective and refills more frequent.

B. Phrenicectomy is being used more as an independent procedure in the treatment for tuberculosis, not only to control certain symptoms but to bring about a cure. It may be indicated in any patient, but probably its most usual indications are:

1. An acute progressive caseous type of tuberculosis when pneumothorax is prevented by adhesions.

2. Chronic types of disease in which pneumothorax cannot be induced and thoracoplasty is contraindicated; phrenicectomy may help on the more badly diseased side.

3. Early cases of unilateral tuberculosis, in which treatment in a sanatorium does not seem to bring about favorable progress.

4. Definitely basal tuberculosis; here phrenicectomy has its most happy effect.

5. To relieve specific symptoms without expecting a cure: (*a*) to relieve the heart from embarrassment caused by extensive displacement produced by the pull of a fibrosed lung; (*b*) to abolish dyspnea and pain resulting from a scarred lung and diaphragmatic adhesions; (*c*) to control hemoptysis; (*d*) to stop incessant coughing and vomiting incident to it, and (*e*) to control hiccups in a hopeless case. Miller [20] reported having done a bilateral phrenicectomy for uncontrollable hiccups.

C. It is used in the following pulmonary conditions:

1. Bronchiectasis, especially when it is unilateral and in the lower lobe.

2. Subacute and chronic pulmonary abscess.

3. A prophylaxis against the development of bronchiectasis after an unresolved pneumonia.

4. Hydatid disease of the lung after marsupialization of the cyst, to reduce the size of the cavity. Davies [21] and Campbell [22] reported such cases.

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19. Weise, Otto: Erfährungen mit der künstlichen Zwerchfellähmung bei der Lungentuberkulose bei Kinder, Beitr. z. Klin. d. Tuberk. **63**:254 (Dec.) 1926.

20. Miller, Felix P.: Avulsion of Phrenic Nerve, Texas State J. Med. **24**:15 (May) 1928.

21. Davies, H. Morriston: An Endeavor to Assess the Value of Hemidiaphragmatic Paralysis by Evulsion of the Phrenic Nerve in the Treatment of Tuberculosis and Bronchiectasis: A Review of 105 Cases, Tubercle **9**:202 (Feb.) 1928.

22. Campbell, A. J.: Diaphragmatic Paralysis as a Therapeutic Measure in Intrathoracic Disease, Quart. J. Med. **21**:463 (July) 1928.

5. For diaphragmatic hernias, Harrington [23] suggested it as a palliative measure when direct operative intervention was contraindicated, and reported several cases in which the patients obtained symptomatic relief.

6. To aid in filling in the defect in the wall of the chest after the removal of malignant neoplasms (Harrington [23] and Jehn [24]).

7. In stab or gunshot wounds of the lungs. Haim [25] and Warner [26] each reported one case in which it was of value in such injuries to the lung.

RESULTS

The reported results of phrenicectomy vary considerably. The great majority deal with tuberculosis, and but scattered cases of bronchiectasis or pulmonary abscess treated by phrenicectomy have been reported. Most writers have reported the final outcome of the disease, rather than the fulfilment or nonfulfilment of the surgeon's expectation of phrenicectomy as being the test of the success of the procedure. Davies [21] and Campbell [22] analyzed their cases with much the same view as we hold in this paper. We feel that phrenicectomy, being in the main a complementary procedure and having many varied and specific indications, should be judged by its success or failure in fulfilling the surgeon's expectation and not necessarily by the ultimate outcome of the disease. For example, on one of our patients who had a chronic suppurative cavernous pneumonitis, phrenicectomy was done to stop repeated hemorrhages. This it did although it had no other effect and further operation was done, after which the patient began to get well. However, we believe that phrenicectomy was a distinct success in fulfilling its indication.

With this view in mind, I have analyzed sixty-three cases in which phrenicectomy has been done at the University Hospital, Ann Arbor. Nine of these were done by F. A. Coller between 1925 and 1927, and fifty-four by John Alexander, one in 1920 and the rest in 1927 and 1928. There are about twenty additional cases which I have not included in this list because the operations were done too recently to judge the outcome. I have been able to follow sixty of the sixty-three cases and for simplicity have divided them into groups.

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23. Harrington, S. W.: Phrenicotomy in the Treatment of Diaphragmatic Hernia, and of Tumors of the Wall of the Chest, Arch. Surg. **18**:561 (Jan.) 1929.

24. Jehn, quoted by Haim, Emil: Zentralbl. f. Chir. **54**:391 (Feb.) 1927.

25. Haim, Emil: Ein Beitrag zur Phrenikotomie, Zentralbl. f. Chir. **54**:391 (Feb.) 1927.

26. Warner, W. P.: Phrenicotomy in Traumatic Injury to the Chest, Canad M. A. J. **16**:427 (April) 1926.

ANALYSIS OF SIXTY-THREE CASES

General.—Temporary phrenic nerve interruption by crushing the phrenic nerve and its accessory nerve (phrenemphraxis) was done on nine patients; the radical phrenicectomy of Goetze was done on twenty-six patients, and evulsion or exeresis of Felix on twenty-eight patients. The operation was performed on the right side twenty-six times and on the left thirty-seven times. Paralysis of the diaphragm was definitely demonstrated by fluoroscopic examination to have been obtained in fifty-eight patients and was indeterminate in five because of obscuration of the diaphragmatic shadow by fluid, thickened pleura or a consolidated lung. We were able to measure fairly accurately the rise of the diaphragm on the left side in twenty-five patients and on the right side in eighteen. The average rise on the left was 4.33 cm., and on the right 4.25 cm., the total average being 4.3 cm. The least rise was 1 cm., and the greatest rise 10 cm., both on the left side. In twenty cases the rise was indeterminate, because the shadow of the diaphragm was obscured for one reason or another or because postoperative films were not made.

Complications met with were only technical. One patient had five phrenic nerves, all of which were not crushed at the first operation, a second being required. Several had more than one accessory nerve, and in several the phrenic nerve was far medial to its normal position. There was no serious hemorrhage, air embolism or infection. There was no operative death.

Several interesting clinical facts were observed. Twenty-nine of forty-six patients, of whom the records are specific about the complaint of cough, showed improvement of the cough shortly after phrenicectomy and seventeen no change. Three of thirty-five patients whose records are accurate showed an increase of an average of 48 per cent in the amount of sputum raised after phrenicectomy; twenty-five showed an average decrease of 58 per cent of the amount of sputum, and seven showed no change in the amount. In forty-eight patients the presence or absence of dyspnea was noted before and after phrenicectomy; two showed a slight increase of an existing dyspnea, three a decrease of an existing dyspnea and forty-three could detect no difference in breathing. One patient vomited for a week after a left-sided phrenicectomy, due apparently to the rise of the stomach.

We feel that the expectation was fulfilled in forty-three, or 68.3 per cent of the sixty-three patients and was partly fulfilled in four, or 6.3 per cent. There was total failure of fulfilment in sixteen, or 25.4 per cent. In other words, in all types of cases phrenicectomy met the expectation three out of four times.

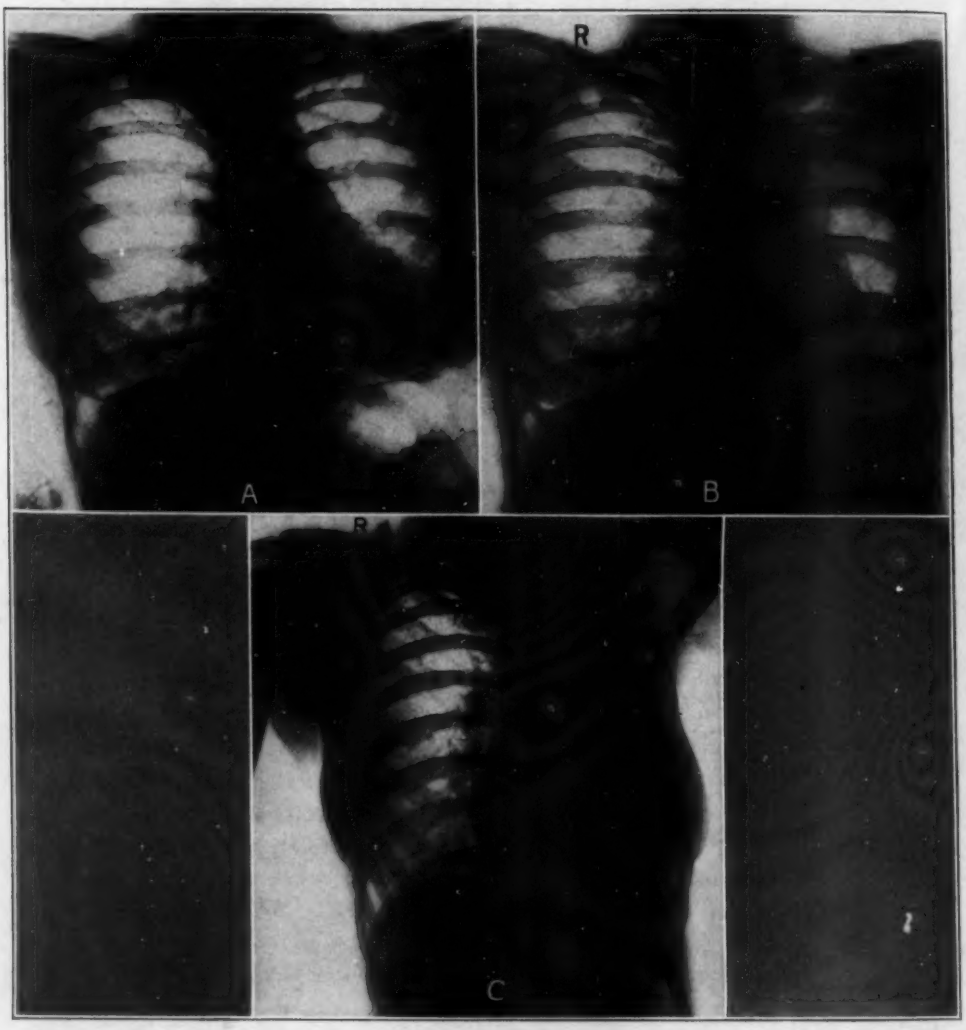

Fig. 1 (G. H.).—*A*, far advanced pulmonary tuberculosis. Cavity of left apex on admission. *B*, five months after phrenicectomy, showing rise of diaphragm, diminution in size of cavity and clearing of left lung. *C*, two months after completed thoracoplasty, showing excellent collapse of left lung.

Detailed Analysis.—In the appended table, the cases are grouped according to diseases for which the operations were done. I have attempted briefly to summarize each group as follows:

Group 1 consists of sixteen cases in which phrenicectomy was done as a preliminary to extrapleural thoracoplasty in order to paralyze the diaphragm, increase pulmonary collapse and test the contralateral lung, and of two case in which phrenicectomy was done preliminary to Schede thoracoplasty, in order to diminish the size of a chronic tuberculous empyemic cavity. All of the patients had far advanced tuberculosis. Figure 1 illustrates the effect of phrenicectomy in a typical case in this group.

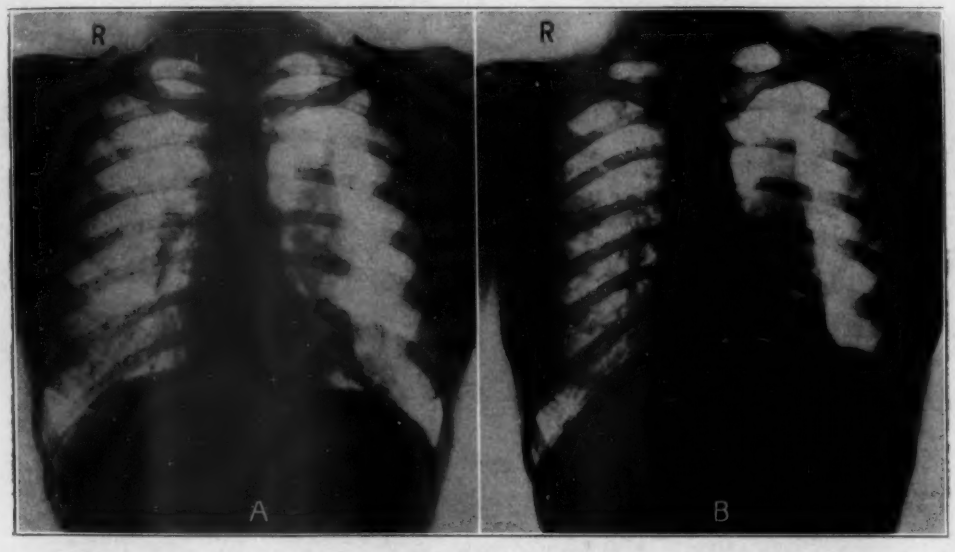

Fig. 2 (H. G.).—*A*, far advanced left pulmonary tuberculosis. Pneumothorax; adhesions at base; adhesions at apex holding open a cavity. *B*, two months after phrenicectomy, showing increased collapse and closure of cavity.

In thirteen of sixteen cases of pulmonary tuberculosis the expectation was fulfilled, as there was a demonstrable paralysis and rise of the diaphragm. In eight of these there was also definite clinical improvement and in one enough improvement so that five months later a thoracoplasty could be done.

In one case of chronic empyema phrenicectomy relieved cough and pain and caused a 2 cm. rise of the diaphragm. In the other case the paralysis and rise of the diaphragm were indeterminate and there was no improvement.

At present five of these patients are well, eight have improved and five are dead.

In group 2 there were five cases of pulmonary tuberculosis in which after phrenicectomy was done to supplement pneumothorax the expectation was fulfilled in 80 per cent. Figure 2 illustrates how phrenicectomy may increase the collapse obtainable by pneumothorax.

The indication in one of the cases was to stop movement of the right side of the diaphragm and to increase the collapse. The condition of the patient improved.

In three cases, phrenicectomy was done to supplement pneumothorax and to increase collapse. In two of the patients the condition improved and in one it was unimproved.

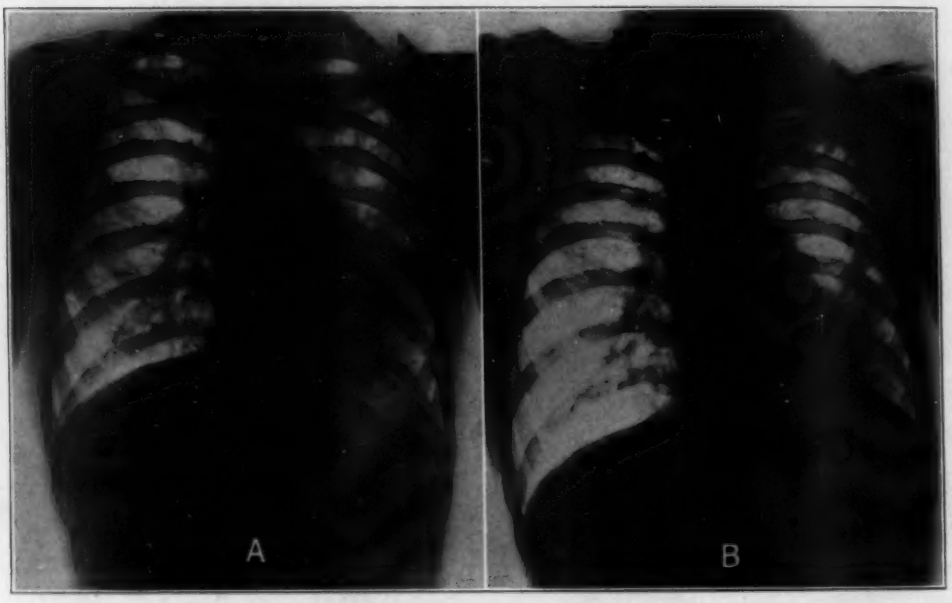

Fig. 3 (E. M.).—*A*, case of far advanced bilateral pulmonary tuberculosis. Worse on the left side. *B*, seven days after phrenicectomy, showing rise of diaphragm. The patient had shown some clinical improvement.

In one case phrenicectomy was done to release the pull of adhesions on the apex and middle lobe, to stop hemoptysis and to increase collapse. The hemorrhages were stopped, and the patient's condition improved.

At present four of these patients have improved and one is worse.

Group 3 consists of four cases of tuberculosis in which phrenicectomy was done as a complement to multiple intercostal neurectomy, one of which is illustrated in figure 3.

Expectation was fulfilled in all four in that there was definite paralysis and paradoxic movement of the diaphragm and in two cases a definite rise of the diaphragm. In one there was improvement after

phrenicectomy alone. All of the patients had far advanced tuberculosis, were not suitable risks for thoracoplasty and nothing was expected from the phrenicectomy alone.

At present one of these patients is well, two have improved and one is worse.

Group 4 consists of eleven cases of pulmonary tuberculosis in which phrenicectomy was used as an independent procedure. The expectation was fulfilled in nine and not in two, a percentage of 82. Figure 4 illustrates a case of this group.

Seven were cases of far advanced tuberculosis involving both lungs, in which pneumothorax could not be induced. In six of these phrenicec-

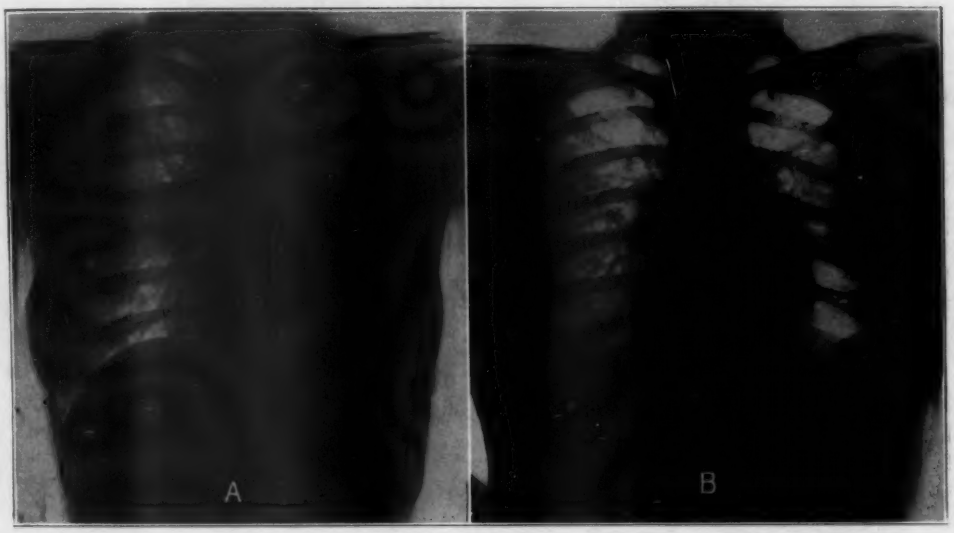

Fig. 4 (A. L.).—*A*, far advanced bilateral pulmonary tuberculosis; worse on the left with a large amount of fibrosis. *B*, twenty months after left phrenicectomy, showing great improvement.

tomy was done to improve the worst side, in four there was improvement and in two there was not. In one case phrenicectomy was done on the worst side to stop repeated hemorrhages, which it did, and improvement followed.

One patient had early tuberculosis in both apexes, and began to have repeated hemorrhages. A left phrenicectomy stopped the bleeding.

One patient had basal tuberculosis with a cavity in the lower lobe. Phrenicectomy greatly improved the lesion but did not quite close the cavity; pneumothorax was induced later.

Two patients had moderately advanced tuberculosis, for which phrenicectomy was done to control the lesions. Both have improved.

One patient with far advanced tuberculosis who was much improved on discharge became worse at home and died two months later.

At present two of these patients are well, five have improved, the condition of one is unchanged, two are dead and the result for one is unknown.

Group 5, represented by figure 5, consists of thirteen cases of bronchiectasis, of which five were right-sided, five left-sided, three bilateral but worse on one side, and two cases of fibrous pneumonitis.

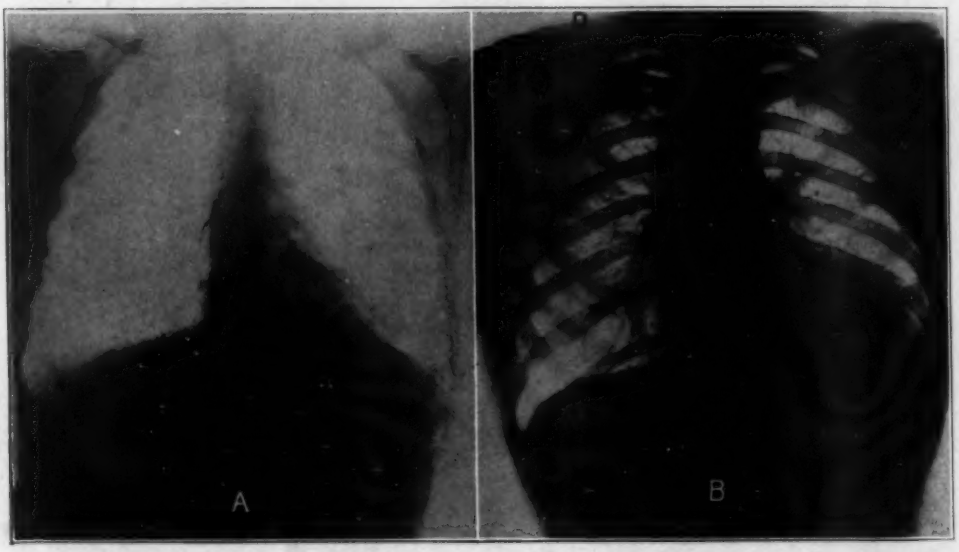

Fig. 5 (G. S.).—*A*, a case of left basal bronchiectasis—injection of iodized oil. *B*, three months after phrenicectomy, showing rise of diaphragm. There was great temporary improvement for three weeks, and the patient is now worse than before phrenicectomy.

The indications in three were palliation and as preliminary to thoracoplasty. In two there was moderate temporary improvement and in one slight temporary improvement, which was not lasting and thoracoplasty was performed.

In three patients the operation was done to supplement pneumothorax. Of these, one has improved slightly, the sputum being reduced 75 per cent, one has improved moderately for sixteen months and one improved moderately for several weeks, but required thoracoplasty later.

In four patients, phrenicectomy was done for palliation of bronchiectasis. One showed what was an apparent cure for two months and could be followed no longer; two showed slight temporary improvement

for a few weeks and then lost it; one showed great improvement for a few weeks and later became worse.

In one case, the operation was done for palliation and as a preliminary to lobectomy. The patient showed great improvement for three weeks and then lost it. After a four-stage lobectomy he is now getting well.

In one case phrenicectomy was done to stop hemorrhages. The patient has had no more hemorrhages and has been greatly improved for eighteen months.

One indication was to relieve the pull on the mediastinum, to relieve dyspnea and as a prophylaxis against further dilatation of the bronchi. The patient has maintained great improvement for two years.

In one case of fibroid pneumonitis, phrenicectomy was done as prophylaxis against dilatation of the bronchi. The patient has been lost from observation.

One patient had a fibroid pneumonia and suffered from great pain due to diaphragmatic adhesions. She was temporarily relieved but the pain is now worse, ten months later.

In these fifteen patients, the expectation was fulfilled in eight, partly in three and not at all in four. Fourteen showed varying degrees of improvement, nine being only temporary. Five have held their improvement to date, the longest period being two years since operation. In only 35 per cent of the patients was improvement more than temporary.

At present five patients in this group have improved, the condition of three is unchanged, two are worse, three are dead and for two the results are unknown.

Group 6 consists of six cases of pulmonary abscess and four of chronic pulmonary suppuration.

In the cases of abscess, phrenicectomy was indicated to stop hemorrhage and improve the abscess in one case, and to cure basal pulmonary abscess in one case. In both the results were unsuccessful, and in the latter thoracoplasty and cautery pneumonectomy were done later, after which the patient recovered. In two cases temporary phrenicectomy followed by postural drainage cured abscesses of the left upper lobe. In one case it was done to cure pulmonary abscess; as the results were unsuccessful, pneumothorax was then induced and was followed by great improvement; five months later the patient was operated on by another surgeon and died. In one case phrenicectomy was done to cure abscess of the upper right lobe; moderate temporary improvement followed lasting for three weeks, then recrudescence of the abscess occurred and required surgical drainage. The patient is now well. Figure 6 illustrates a case of pulmonary abscess in which the patient was cured by phrenicectomy.

One patient in group 6 had a small chronic supradiaphragmatic empyema with a bleeding bronchopleural fistula. A phrenicectomy completely cured him.

In one patient, phrenicectomy was done for palliation of left basal chronic suppurative cavernous pneumonitis. Postural drainage was then instituted, and he is greatly improved five months later.

Phrenicectomy was done, after pneumothorax failed, as a preliminary to thoracoplasty on a patient with chronic pulmonary suppuration and subacute empyema. It was of no benefit, and the patient died after thoracoplasty.

In one case of chronic cavernous and suppurative pneumonitis phrenicectomy was done to stop repeated hemorrhages. This it did,

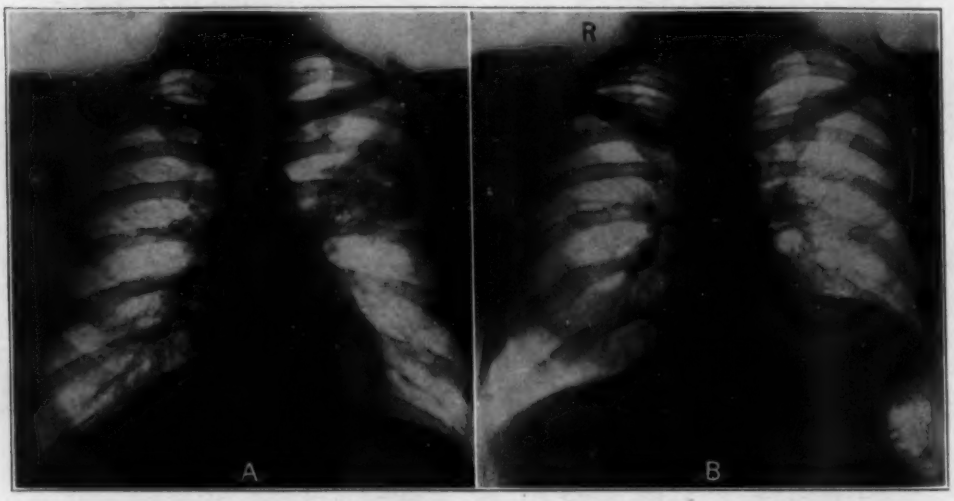

Fig. 6 (L. B.).—*A*, case of pulmonary abscess of the left upper lobe. *B*, ten weeks after temporary phrenicectomy, showing rise of diaphragm. Abscess completely healed.

but subsequent drainage was required and the patient is now getting well.

The expectation was fulfilled in five of these ten patients. At present four patients in this group are well, three have improved and three are dead.

CONCLUSIONS

In evaluating the results of phrenicectomy in this series of cases, I have tried to determine in each instance whether phrenicectomy did what was expected of it or not. In pulmonary lesions, in which phrenicectomy was used as an independent procedure, improvement of the patient was the criterion for its success. However, in cases in which

phrenicectomy was used supplementary to thoracoplasty, intercostal neurectomy or pneumothorax, some of the patients did not show improvement from the phrenicectomy alone. The operation, however, was considered successful when the anatomic result (paralysis and rise of the diaphragm) did increase the compression obtained by thoracoplasty, the amount of relaxation of the lung produced by intercostal neurectomy and the degree of collapse in cases of artificial pneumothorax. The success or failure of compression therapy in these cases must rightly be credited to thoracoplasty, intercostal neurectomy or pneumothorax.

After analyzing a series of sixty-three cases with follow-up reports of sixty, it is found that phrenicectomy fulfilled its expectation in 75 per cent of a wide variety of pulmonary diseases. As alleviation rather than cure was the most that could be expected in a great majority of cases, it was necessary to employ further surgical procedures. From the experience of the surgical department of the University Hospital, I have drawn several conclusions, as follows:

1. Phrenicectomy is a procedure of definite value in the surgical treatment for pulmonary diseases. It has numerous indications, but in a large majority of instances, it will be only a step in the surgical intervention of various pulmonary lesions, and one must be prepared to proceed with further measures when indicated.

2. Its widest field of application is in the treatment for predominantly unilateral pulmonary tuberculosis.

I believe that it should be used preliminary to every extrapleural thoracoplasty.

As a supplement to artificial pneumothorax therapy, I believe that it definitely enhances the value of this form of treatment, and will change many cases of unsatisfactory collapse into satisfactory ones. I believe that it should be used much more frequently that is the general custom.

Combined with multiple intercostal neurectomy, phrenicectomy offers a chance for cure in a small number of patients in whom pneumothorax or thoracoplasty should not or cannot be done.

As an independent procedure in the treatment for pulmonary tuberculosis, its indications are rapidly growing. In selected cases one can expect improvement from phrenicectomy alone in 80 per cent.

3. In bronchiectasis one may occasionally obtain a brilliant cure, but as a rule the most that can be expected of phrenicectomy is improvement that is not permanent. In early cases of unilateral disease, phrenicectomy combined with subsequent postural drainage is the treatment of choice. I believe that it should be seriously considered as a prophylaxis against bronchiectasis in every case of so-called fibroid pneumonia.

Patient Age	Sex	Diagnosis	Indication	Operation and Date	Fulfilment of Expectation	Paralysis and Paradoxic Movement of Diaphragm, Period Since Operation	Rise of Diaphragm, Period Since Operation	Clinical Effect of Phrenicectomy	Subsequent Treatment
GROUP 1.—*Preliminary to Thoracoplasty—Far Advanced Pulmonary Tuberculosis*									
F. B. 26	♀	Far advanced tuberculosis with fibrosis; mainly on left	Preliminary to thoracoplasty	Left phrenicectomy 1/8/25	Yes	+ 1 month	10 cm. 1 month	Slight improvement	Two-stage thoracoplasty, February, 1925
R. F. 30	♂	Far advanced tuberculosis of left apex, with cavity	Preliminary to thoracoplasty	Left exeresis 12/31/26	Yes	+ 6 days	6 cm. 6 days	Slight improvement	Two-stage thoracoplasty, January, 1927
R. M. R. 29	♂	Far advanced tuberculosis of left apex, with cavity; early lesion of right apex	Preliminary to thoracoplasty	Left phrenicectomy 2/20/26	Yes	+ 3 days	2 cm. 3 days	Slight improvement	Two-stage thoracoplasty, March, 1926
L. N. 24	♀	Far advanced fibrotic tuberculosis of right lung	Preliminary to thoracoplasty	Right exeresis, 10 cm. 5/22/23	Yes	+ 5 days	2 cm. 5 days	No improvement	Two-stage thoracoplasty, June, 1926
G. M. L. 26	♀	Far advanced tuberculosis of left lung; healed lesion of right apex; tuberculous salpingitis and peritonitis	Preliminary to thoracoplasty	Left exeresis, 10 cm. 4/9/26	Yes	+ 7 days	5 cm. 7 days	No improvement	Two-stage thoracoplasty, May, 1926
D. G. F. 43	♂	Far advanced tuberculous cavitation of right side	Preliminary to thoracoplasty	Right exeresis, 35 cm. 5/17/27	Yes	+ 5 days	5 cm. 5 days	No improvement	Two-stage thoracoplasty, June, 1927; death, July 29, 1927
O. R. S. 22	♂	Far advanced tuberculosis of right lung with cavity; small lesion of left apex	Preliminary to thoracoplasty	Right exeresis, 12.5 cm. 1/30/28	Yes	+ 3 weeks	3 cm. 3 weeks	Improvement	Improved for a while; pneumothorax attempted and failed; two-stage thoracoplasty, June, 1928
E. K. 20	♀	Chronic tuberculosis of left lung with pleural effusion	Preliminary to thoracoplasty	Left phrenicectomy 3/2/27	No	Indeterminate	Indeterminate	No improvement	Three-stage thoracoplasty, March-April, 1927
G. W. L. 21	♂	Chronic left pulmonary tuberculosis with pleural effusion; tuberculous enteritis	Preliminary to thoracoplasty	Left exeresis 10/31/27	Yes	+ 1 day	1 cm. 1 day	Improvement	Two-stage thoracoplasty, November, 1927
C. F. 23	♂	Chronic pulmonary tuberculosis with tuberculous empyema of left side	Preliminary to thoracoplasty	Left phrenicectomy 5/5/28	No	Indeterminate	Indeterminate	No improvement	Four-stage thoracoplasty, May-June, 1928
D. B. 28	♂	Far advanced fibrotic tuberculosis of left lung	Preliminary to thoracoplasty	Left exeresis, 34 cm. 8/15/28	Yes	+ 1 week	2 cm. 1 week	No improvement	Two-stage thoracoplasty, September, 1928
E. Y. 24	♀	Chronic bilateral tuberculosis; right tuberculous empyema	Preliminary to Schede thoracoplasty	Right phrenicectomy 8/30/28	No	Indeterminate	Indeterminate	No improvement	Three-stage Schede thoracoplasty, October, 1928
B. D. H. 27	♂	Chronic tuberculosis of right lung with complete tuberculous empyema	Preliminary to Schede thoracoplasty	Right phrenicectomy 12/21/28	Yes	Yes 1 day	2 cm. 1 month	Improvement; relieved from cough and pain	Three-stage Schede thoracoplasty, February, 1929
G. A. 36	♀	Chronic tuberculosis of left lung with cavity; left tuberculous empyema	Preliminary to thoracoplasty	Left exeresis, 37.5 cm. 6/22/28	No	Indeterminate	Indeterminate	No improvement	Three-stage thoracoplasty, November, 1928
E. O 19	♂	Far advanced tuberculosis of left lung with cavity	Preliminary to thoracoplasty	Left exeresis, 8 cm. 8/3/28	Yes	+ 6 days	6 cm. 6 days	Improvement	Two-stage thoracoplasty, September, 1928
G. H. 24	♀	Far advanced tuberculosis of left lung with cavity	Preliminary to thoracoplasty	Left exeresis, 12 cm. 7/23/28	Yes	+ 7 days	5 cm. 7 days	Improvement	Two-stage thoracoplasty, December, 1928
E. L. 21	♀	Far advanced tuberculosis of left lung with cavity and pyopneumothorax	Preliminary to thoracoplasty	Left phrenicectomy 11/21/28	Yes	+ 7 days	Indeterminate	Improvement	Three-stage thoracoplasty, January-February, 1929
E. M. 40	♀	Far advanced tuberculosis of left lung with cavity	Preliminary to thoracoplasty	Left exeresis, 23 cm. 12/15/28	Yes	+ 6 days	1.5 cm. 6 days	No improvement	Two-stage thoracoplasty, January-February, 1929
GROUP 2.—*Supplementary to Artificial Pneumothorax—Cases of Pulmonary Tuberculosis*									
J. E. K. 20	♀	Moderately advanced pulmonary tuberculosis; tuberculous colitis	To supplement pneumothorax to stop movement of right side of diaphragm and to lengthen interval between refills	Right phrenicectomy 5/5/27	Yes	+ 2 mo.	3.5 cm. 2 mo.	Improvement	Pneumothorax stopped after 1 year of rest

* The following abbreviations and symbols are found in the table: ♀, female; ♂, male; Sl., slight; Occ., occasionally; Mod.,

for Which Operations Were Done *

Signs and Symptoms																	
Cough			Amount of Sputum			Ease of Expectoration			Dyspnea			Temperature, Fahrenheit					
On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	Condition of Patient on Last Report	Comment
GROUP 1.—*Preliminary to Thoracoplasty—Far Advanced Pulmonary Tuberculosis*																	
.....	.....	Slight	.....	.....	0	.....	.....	Easier	Yes	.....	0	99	.....	98.6	Well	Married later; one child 15 mo. old
Mod.	Mod.	No	300 cc.	.....	0	.....	.....	.....	Yes	.....	No	99	99	98.3	Well	Works 8 hours a day; moderate exercise
Severe	.....	None	50 cc.	.....	None	.....	.....	No difference	Yes	Yes	No	99	99	98.6	Well 3 years	Works 8 hours a day for 2 years; skates; skis
Severe	.....	Slight	300 cc.	.....	50 cc.	.....	.....	.....	Yes	.....	Sl.	100	100	98.6	Improved	Married
Mod.	.....	None	.....	.....	15 cc.	.....	.....	Easier	Yes	.....	No	100	100	98.6	Well	Taught last year; found it strenuous
Severe	.....	.....	450 cc.	.....	.....	.....	.....	.....	Yes	Yes	....	100	99	.....	Died	Cause of death miliary tuberculosis; ball; thrombus left side of heart
Severe	Less severe	Slight	400 cc.	90 cc.	15 cc.	.....	.....	More difficult	Yes	Yes	No	99	99	98.6	Well	Works as salesman
Mod.	.....	.....	.....	.....	.....	.....	.....	.....	Yes	Yes	....	101	101	.....	Died	Died on 4/23/27 of tuberculous meningitis
Mod.	Less	None	150 cc.	75 cc.	0	.....	.....	.....	Yes	Yes	Yes	99	98.6	98.6	Improved	Still on cure
Slight	Slight	No	.....	0	0	.....	.....	.....	.....	.....	No	99	99	98.6	Improved	Still on cure
Mod.	Slight	None	90 cc.	60 cc.	0	.....	.....	Easier	Yes	Yes	No	100	98.8	98.4	Improved	Gained 20 pounds; still on cure but much improved 6 mo. after operation
Slight	Slight	.....	0	0	.....	.....	No change	.....	Yes	Yes	....	99	99	.....	Died	Died of influenza, pneumonia 3 mo. later
Mod.	Slight	Slight	10 cc.	10 cc.	10 cc.	Difficult	Easier	Easier	Yes	Yes	Yes	101	101	100	Improved	Not yet well after Schede thoracoplasty
Mod.	Mod.	Slight	30 cc.	30 cc.	5 cc.	Easy	Easy	Easy	Yes	Yes	Yes	99.6	99.6	98.6	Improved	Still on cure 4 mo. after thoracoplasty
Mod.	Better	0	240 cc.	180 cc.	30 cc.	Easy	Easy	Easy	No	No	No	99	98	98	Improved	Still on cure
Mod.	Mod.	Slight	50 cc.	5 cc.	5 cc.	.....	Easier	Easy	Yes	Yes	No	98.6	98.6	98.6	Improved	Still on cure
Severe	Mod.	Severe	90 cc.	60 cc.	200 cc.	Severe	Easy	Severe	Yes	Yes	Yes	100.6	99	102	Worse	Patient has developed spread in right lung
Mod.	Mod.	Mod.	15 cc.	15 cc.	30 cc.	.....	No difference	.....	Yes	Yes	.....	98.6	98.6	....	Died	Died 17 days after thoracoplasty from spread to right lung
GROUP 2.—*Supplementary to Artificial Pneumothorax—Cases of Pulmonary Tuberculosis*																	
Mod.	Less	None	.....	0	0	.....	.....	.....	Mod.	Mod.	Sl.	98.6	98.6	98.6	Improved	Lung allowed to re-expand; 1 year after phrenicectomy condition good; no râles or symptoms

moderate; Imp., improvement; Temp., temporary.

Patient Age Sex	Diagnosis	Indication	Operation and Date	Fulfilment of Expectation	Paralysis and Paradoxic Movement of Diaphragm, Period Since Operation	Rise of Diaphragm, Period Since Operation	Clinical Effect of Phrenicectomy	Subsequent Treatment
J. J. S. 37 ♂	Far advanced tuberculosis, mainly on left with cavitation; diabetes	To supplement pneumothorax and to increase collapse of left lung	Left exeresis, 35 cm. 10/4/27	No	+ 10 days	6 cm. 12 mo.	Temporary slight improvement	Continuance of pneumothorax and rest
M. L. B. 22 ♀	Far advanced tuberculosis, mainly on right	To supplement pneumothorax; to release pull of adhesions at apex and middle lobe, and to stop hemoptysis	Right phrenicectomy 10/24/28	Yes	+ 1 day	Indeterminate	Improvement	Continuance of pneumothorax and rest
Mrs. T. B. 26 ♀	Far advanced tuberculosis of right lung	To supplement pneumothorax and to increase collapse	Right exeresis, 11.5 cm. 10/29/28	Yes	+ 1 day	Indeterminate	Improvement	Continuation of pneumothorax and rest
B. E. H. 51 ♀	Far advanced tuberculosis of left lung	To supplement pneumothorax and to obtain greater collapse	Right phrenicectomy 10/24/28	Yes	+ 1 day	Indeterminate	Improvement	Continuation of pneumothorax and rest
GROUP 3.—*Supplementary to Intercostal Neurectomy—Cases of Pulmonary Tuberculosis*								
Mrs. L. W. 56 ♀	Far advanced pulmonary tuberculosis, mainly on right side with cavitation	Preliminary to multiple intercostal neurectomy after failure to induce pneumothorax	Right phrenicectomy 10/27/27	Yes	+ 1 mo.	Indeterminate 1 mo.	No improvement	Multiple intercostal neurectomy of nerves 2 to 9 on right side, 11/29/27
M. B. 28 ♀	Far advanced tuberculosis, mainly on left	Preliminary to multiple intercostal neurectomy after failure of pneumothorax therapy	Left exeresis, 7 cm. 11/11/27	Yes	+ 2 mo.	3 cm. 2 mo.	Slight improvement	Multiple intercostal neurectomy of nerves 2 to 10, 2/2/28
E. W. M. 17 ♂	Far advanced pulmonary tuberculosis, mainly on left	Preliminary to multiple intercostal neurectomy	Left exeresis, 25 cm. 8/24/28	Yes	+ 7 days	4 cm. 7 days	No improvement	Multiple intercostal neurectomy of nerves 2 to 11, 9/1/28
M. L. McG. 27 ♂	Far advanced pulmonary tuberculosis, mainly on left side; cavitation; tuberculous laryngitis; tuberculous enteritis	Preliminary to multiple intercostal neurectomy	Left phrenicectomy 6/23/28	Yes	+ 3 days	Indeterminate 3 mo.	No improvement	Multiple intercostal neurectomy of nerves 2 to 11, 6/29/28
GROUP 4—*Independent Operations for Pulmonary Tuberculosis*								
H. J. H. 29 ♂	Chronic bilateral pulmonary tuberculosis; cavity of upper right; been on cure 6 years	To improve right and to test left side	Right exeresis, 12.5 cm. 11/10/27	Yes	+ 2½ yr.	5.5 cm. 2½ yr.	Improvement	Rest
Mrs. A. A. L. 27 ♀	Far advanced tuberculosis of left lung; cavitation (?); some involvement of right lung	To stop repeated hemorrhages	Left exeresis 12/17/26	Yes	+ 6 mo.	4.5 cm. 6 mo.	Improvement	Rest
G. L. 24 ♂	Far advanced tuberculosis; cavitation on left; moderately advanced on right, regressive	To control progressive lesions	Left phrenicectomy 10/26/28	Yes	+ 2 mo.	2.5 cm. 2 mo.	Improvement	Rest
Mrs. R. M. S. 25 ♀	Early tuberculosis of both apexes	To control hemoptysis	Right exeresis, 25 cm. 10/7/28	Yes	+ 3 mo.	5 cm. 3 mo.	Improvement	Partial rest
H. J. B. 13 ♀	Progressive bilateral pulmonary tuberculosis, worse on left	To control progressing left lesions	Left temporary phrenicectomy 11/16/28	No	+ 4 days	2 cm. 2 mo.	Temporary improvement	Rest

Which Operations Were Done—Continued

Signs and Symptoms																
Cough			Amount of Sputum			Ease of Expectoration			Dyspnea			Temperature, Fahrenheit				
On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	Condition of Patient on Last Report	Comment
Severe	Less	Slight	90 cc.	60 cc.	60 cc.	.....	Easier	Easier	No	No	No	98.6	98.6	98.6	Worse	Improved for a while; spread to other lung; now pyopneumothorax
Mod.	Less	Slight	30 cc.	.....	0	.....	.....	.....	Yes	Yes	Yes	98.6	98.6	98.6	Improved	Still on cure; much improved
.....	.....	.....	.....	.....	0	.....	.....	.....	Sl.	Sl.	Sl.	99	99	98.6	Improved	Still on cure
.....	.....	.....	.....	.....	0	.....	.....	.....	Sl.	Sl.	Sl.	99	99	98.6	Improved	Still on cure
GROUP 3.—*Supplementary to Intercostal Neurectomy—Cases of Pulmonary Tuberculosis*																
Severe	.....	Slight	120 cc.	.....	10 cc.	.....	.....	Easier	Yes	Yes	Yes	99.4	99	98.6	Well	Writes that she is well and working
Mod.	Less	None	.....	Less	2 cc.	.....	.....	.....	Yes	Yes	Yes	98.6	98.6	98.6	Improved	Still on cure; is greatly improved and considers herself well
Mod.	.....	Slight	60 cc.	.....	None	.....	.....	.....	.....	.....	.....	99	99	98.6	Improved	Still on cure
Mod.	No difference	Mod.	60 cc.	60 cc.	150 cc.	Difficult	Difficult	More difficult	Mod.	Mod.	Sl.	100	100	99.6	Worse	Still on cure; worse
GROUP 4.—*Independent Operations for Pulmonary Tuberculosis*																
Mod.	Imp.	Slight	60 cc.	30 cc.	30 cc.	.....	No difference	.....	Yes	Worse for a while	Same as at first	99	99	98	Improved	Still on cure; reexamined March 1, 1929, showed cavity ⅓ former size; both lungs much improved; general condition improved
Mod.	Imp.	None	.....	Decreased	0	.....	.....	.....	No	No	No	100	99	98.6	Improved	Occasional light housework; clinically arrested
.....	.....	.....	180 cc.	120 cc.	.....	.....	Easier	.....	Yes	Yes	.....	99.4	98.3	....	No report	Transferred to another sanatorium 3 mo. after phrenicectomy
None	None	None	None	None	None	.....	.....	.....	Occ. sl.	Occ. sl.	Occ. sl.	98.6	98.6	98.6	Improved	No hemoptysis; x-rays show clearing; feels well; light housework
Slight	Slight	None	5 cc.	5 cc.	5 cc.	.....	Easier	.....	No	No	No	98.6	98.6	98.6	Unchanged	Still on cure; some roentgen clearing on right and left

Patient Age	Sex	Diagnosis	Indication	Operation and Date	Fulfilment of Expectation	Paralysis and Paradoxic Movement of Diaphragm, Period Since Operation	Rise of Diaphragm, Period Since Operation	Clinical Effect of Phrenicectomy	Subsequent Treatment
D. A. 28	♂	Far advanced tuberculosis of both lungs; worse on left with cavities	To control extensive left lesions	Left temporary phrenicectomy 11/16/28	Yes	+ 2 mo.	9 cm. 2 mo.	Improvement	Rest
W. A. 63	♂	Far advanced tuberculosis, mainly on left with cavitation; tuberculosis of knee	To control extensive left lesions after failure to induce pneumothorax	Left phrenicectomy 11/18/27	Yes	+ 1 year	8 cm. 1 year	Improvement	Rest
J. Q. 63	♂	Far advanced tuberculosis, more on left (Indian)	To control progressive left lesions	Left phrenicectomy 2/11/27	No	+ 2 days	8 cm. 2 mo.	No improvement	Rest; artificial pneumothorax attempted
C. E. E. 38	♂	Moderately advanced tuberculosis of right lung; diabetes	To control lesions after failure to induce pneumothorax	Right phrenicectomy 8/8/28	Yes	+ 2 mo.	4 cm. 2 mo.	Improvement	Rest
Mrs. A. T. 35	♀	Right basal tuberculosis with cavity	To control right basal lesion	Right exeresis 2/16/27	Yes partly	+ 3 mo.	7 cm. 3 mo.	Improvement	Rest; artificial pneumothorax to finish closing cavity on May 5, 1927
Mrs. E. C. P. 27	♀	Moderately advanced tuberculosis of left lung	To control left lesions after induction of pneumothorax failed	Left exeresis, 32 cm. 11/10/27	Yes	+ 1 day	Indeterminate	Improvement	Rest
				GROUP 5.—*Cases of Bronchiectasis*					
G. K. ..	♂	Bronchiectasis of right lower lobe	Bronchiectasis	Temporary right phrenicectomy 11/1/20	Yes	+ 7 days	Indeterminate; films lost	Excellent improvement	Postural drainage
Mrs. D. W. 68	♀	Bronchiectasis of left base	To supplement pneumothorax therapy	Left phrenicectomy 10/5/27	Yes	+ 5 days	7 cm. 5 days	Moderate improvement	Postural drainage
Geo. C. 20	♂	Extensive bronchiectasis of left lung	Preliminary to thoracoplasty	Left phrenicectomy 5/9/27	Yes	+ 1 day	Indeterminate	Moderate improvement; temporory	Several stage thoracoplasty, Aug. to Oct., 1927; cautery pneumonectomy, January-February, 1928
H. S. S. 19	♀	Bilateral bronchiectasis, mainly of right	Palliation of bronchiectasis	Right phrenicectomy 11/30/27	No	+ 4 days	2 cm 8 mo.	Slight improvement; temporary	Postural drainage
A. E. N. 59	♂	Left hilar bronchiectasis; arteriosclerosis; myocarditis	Palliation	Left temporary phrenicectomy 5/15/28	No	+ 2 days	3 cm. 1 mo.	Great improvement; temporary	Postural drainage
Mrs. M. T. 34	♀	Chronic bilateral basal bronchiectasis; mainly on left	Palliation	Left exeresis, 10 cm., and cut nerve to sub. c. 6/27/28	Partly	+ 2 days	Indeterminate 3 mo.	Slight improvement; temporary	Postural drainage
G. S. 19	♂	Bronchiectasis of left lower lobe	Palliative and preliminary to lobectomy	Left exeresis 9/26/28	Yes	+ 2 mo.	2 cm. 2 mo.	Great improvement; temporary	Four-stage lobectomy, Dec., 1928 to Feb., 1929
D. LaF 27	♂	Left bronchiectasis; sicca; left pulmonary fibrosis	Prophylaxis against further dilatation of bronchi	Left phrenicectomy 5/5/28	?	+ 4 days	2 cm. 4 days	.....	.....
Mrs. M. A. B. 47	♀	Painful right diaphragmatic adhesions; right basal fibrous pneumonitis	Prophylaxis against bronchiectasis and to relieve pain from diaphragmatic adhesions	Right phrenicectomy 5/17/28	No, except temporary relief	+ 7 days	3 cm. 7 days	Temporary	.....

Which Operations Were Done—Continued

Signs and Symptoms																	
Cough			Amount of Sputum			Ease of Expectoration			Dyspnea			Temperature, Fahrenheit					
On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	Condition of Patient on Last Report	Comment
Mod.	.....	.....	.....	.....	.....	.....	.....	.....	No	No	No	99	98.6	98.6	Improved	Wife writes that he is improved
Mod.	Imp.	.....	150 cc.	100 cc.	.....	.....	.....	.....	Yes	Yes	.....	100	99	....	Died	Died on Feb. 27, 1929
Severe	No change	.....	200 cc.	200 cc.	.....	.....	.....	.....	.....	Yes	Yes	101	101	....	Died	Died 3 mo. after phrenicectomy
0	Slight	.....	0	10 cc.	240 cc.	.....	.....	.....	.....	.....	.....	100	99.4	....	Improved	Vomited 1 week after phrenicectomy; no note since; discharged on Oct. 1, 1928
Mod.	.....	.....	150 cc.	25 cc.	0	.....	.....	.....	No	No	No	101	100	98.6	Well	Does light housework
Mod.	Less	None	.....	Less	None	.....	.....	.....	Sl.	Sl.	No	99	98.6	98.6	Well	Works 7 hours a day; considers herself well
GROUP 5.—*Cases of Bronchiectasis*																
Severe	None	.....	400 cc.	0	.....	.....	.....	.....	No	No	.....	99	98	....	Improved 2 mo. later	Followed for 2 mo.; unable to locate
Mod.	.....	No	160 cc.	.....	40 cc.	.....	.....	Easier	No	No	No	98.6	98.6	98.6	Improved	Still on continuous postural drainage
Severe	Severe	Mod.	600 cc.	300 cc.	240 cc.	.....	.....	Harder	Yes	Yes	Yes	99	99	98	Improved	Not well; able to do some work; bronchopleural fistula
Mod.	Imp.	Imp.	90 cc.	160 cc. 2 mo. later	90 cc.	.....	.....	Easier	Yes	Yes	Yes	99	99	98.6	Unchanged	General condition has improved
Severe	Mod.	Severe	240 cc.	30 cc. 1 mo.	240 cc.	.....	.....	No difference	Yes	Yes	Yes	99	99	99	Worse	In hospital; much worse; pain, weakness, cough
Mod.	Mod.	Mod.	120 cc.	200 cc. 1 mo.	80 cc.	.....	.....	Easier	Yes	Yes	Yes	100	99	99	Unchanged	No change; considers herself improved; return of function of diaphragm
Severe	Temp. imp.	Slight	160 cc.	40 cc. 2 wk.; 300 cc. 2 mo.	5 cc.	.....	Easier	.....	Yes	Yes	Yes	Frequent rise	98.6	98.6	Improved	Now up and about; condition rapidly improving; has bronchial fistula to be closed at later date
None	None	.....	0	0	.....	.....	.....	.....	No	No	.....	99	99	....	.....	No report
No	No	No	0	0	0	.....	.....	.....	0	0	0	99.2	99	98.6	Worse	Patient writes that she is worse

Patient Age	Sex	Diagnosis	Indication	Operation and Date	Fulfilment of Expectation	Paralysis and Paradoxic Movement of Diaphragm, Period Since Operation	Rise of Diaphragm, Period Since Operation	Clinical Effect of Phrenicectomy	Subsequent Treatment
O. K. 44	♂	Bronchiectasis; suppurative pneumonitis; lung abscess	To supplement pneumothorax therapy	Right phrenicectomy 12/4/25	Yes, for a while	+ 10 days	2 cm. 10 days	Temporary	Rib resection and drainage; pulmonary abscess, 1/26/27
E. M. H. 22	♀	Bilateral bronchiectasis; mainly on left	Palliation and as preliminary to thoracoplasty	Left phrenicectomy 2/7/27	Yes	+ 7 days	3 cm. 7 days	Moderate improvement; temporary	First stage thoracoplasty, 3/7/27; appendectomy, 4/4/27
W. M. C. 22	♂	Right bronchiectasis; right lung abscess	Palliation and a preliminary to thoracoplasty	Right exeresis 6/2/28	Yes	+ 2 days	5 cm. 2 days	Slight improvement; temporary	Three-stage thoracoplasty, August, 1928
H. M. 29	♂	Syphilis; left fibrous pneumonitis; atelectasis and bronchiectasis	To relieve pull on mediastinum; to relieve dyspnea, and as prophylaxis against further embarrassment of heart	Left phrenicectomy 4/1/27	Yes	+ 25 days	Indeterminate 25 days	Slight improvement	Antisyphilitic
M. L. S. 17	♀	Right bronchiectasis, extensive	To supplement pneumothorax and to increase collapse	Right exeresis 12/10/28	Partly	+ 2 weeks	Indeterminate 2 weeks	Slight improvement	Continuation of pneumothorax and rest
G. M. S. 30	♀	Bronchiectasis of right middle lobe, mild	To check hemoptysis	Right exeresis 6/16/28	Yes	+ 2 days	Rise; indeterminate 3 mo.	Great improvement	Rest for 4 months
			GROUP 6.—*Cases of Pulmonary Suppuration*						
M. L. C. 61	♀	Abscess of lung, right upper lobe; hemoptysis	For hemoptysis and treatment for lung abscess	Right phrenicectomy 5/26/26	No	+ 7 days	5 cm. 7 days	No improvement	Thoracoplasty, first stage 6/4/26; 2d stage 3/23/27
H. A. L. 26	♂	Chronic empyema with bleeding; bronchopleural fistula	To stop hemoptysis	Right exeresis, 33 cm. 2/3/27	Yes	+ 10 days	Rise; indeterminate	Great improvement	.....
W. O. 30	♂	Lung abscess; chronic nephritis; arteriosclerosis; neuroretinitis; epilepsy	For right basal lung abscess	Right exeresis, 24 cm. 10/8/27	No	+ 2 days	Rise; 5 cm.; 2 days	Slight improvement; temporary	Thoracoplasty and cautery; pneumonectomy, December, 1927; January, 1928
T. O. 39	♀	Chronic right pulmonary suppuration with subacute empyema	After pneumothorax failed as preliminary to thoracoplasty	Right exeresis 1/14/28	No	Indeterminate	Indeterminate	No improvement	1/26/28 to 1/31/28, two-stage exploratory thoracotomy; 3/17/28, first stage thoracoplasty
S. H. D.	♂	Abscess of upper left lobe of lung	For lung abscess	Temporary left phrenicectomy 6/16/28	Yes	+ 8 days	3 cm. 8 days	Great improvement	Postural drainage
L. O. B. 28	♂	Subacute abscess of lung, upper left lobe	For lung abscess	Temporory left phrenicectomy 10/6/28	Yes	+ 4 days	4 cm. 4 days	Great improvement	Postural drainage
G. L. D. 30	♂	Left basal chronic suppurative cavernous pneumonitis	Palliation	Left phrenicectomy 10/6/28	Yes	+ 4 days	Indeterminate	Great improvement	Postural drainage
J. R. 33	♂	Abscess of right lower lobe of lung	Lung abscess	Temporary right phrenicectomy 7/21/28	No	+ 1 week	3.5 cm. 1 week	Slight improvement; temporary	Pneumothorax induced Aug. 15, 1928
J. D. 28	♀	Lung abscess upper right lobe	Lung abscess	Temporary right phrenicec- 10/2/28	No	+ 2 days	2.5 cm. 21 days	Moderate improvement; temporary	Postural drainage; two-stage drainage of lung abscess, December, 1928
T. C. 13	♀	Left chronic pulmonary suppuration complicated by osteomyelitis of right femur	For severe hemoptysis	Temporary left phrenicectomy 1/7/29	Yes	+ 1 week	Rise indeterminate	Slight improvement; temporary	Drainage of lung abscess February, 1929

Which Operations Were Done—Continued

Signs and Symptoms																	
Cough			Amount of Sputum			Ease of Expectoration			Dyspnea			Temperature, Fahrenheit					
On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	On Admission	After Phrenicectomy	On March 1, 1929	Condition of Patient on Last Report	Comment
Severe	Mod.	.....	450 cc.	200 cc.	.....	.....	Easier	.....	.....	.....	.....	101	100	....	Died	Died 8 days after thoracotomy; autopsy showed large lung abscess connecting with a bronchiectatic abscess
Severe	Severe	.....	600 cc.	150 cc.	.....	.....	Easier	.....	.....	.....	.....	100	100	....	Died	Died of pneumonia on other side 30 days after thoracoplasty
Severe	.....	.....	250 cc.	150 cc.	.....	.....	.....	.....	.....	.....	.....	98.6	98.6	....	Died	Died 25 days after last stage thoracoplasty
Mod.	Less	Mod.	60 cc.	30 cc.	60 cc.	.....	.....	More difficult	Mod.	None	None	98.6	98.6	98.6	Improved	Two years later patient states he is well
Slight	Slight	Slight	60 cc.	15 cc.	15 cc.	.....	No difference	.....	Sl.	Sl.	Sl.	98.6	98.6	98.6	Unchanged	Still in hospital
Slight	None	Slight	5 cc.	5 cc.	5 cc.	.....	.....	.....	No	No	No	99.2	99.2	98.6	Improved	Feels much better; gained 10 pounds
GROUP 6.—*Cases of Pulmonary Suppuration*																	
Severe	Severe	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	101	....	Died	Died of pulmonary hemorrhage 12 days after last thoracoplasty
Mod.	Imp.	None	20 cc.	0	0	.....	Easier	Easy	Yes	No	No	99	98.6	98.6	Well	Well 2 years later; works; no hemorrhages since phrenicectomy
Mod.	Temp. imp.	Slight	200 to 300 cc.	100 to 200 cc.	5 to 10 cc.	.....	More difficult	More difficult	Yes	.....	Occ.	102	100	98.6	Improved	Patient is free from lung abscess; has a bronchocutaneous fistula; is in hospital for treatment for nephritis
Severe	Severe	.....	500 cc.	.....	.....	.....	.....	.....	Yes	.....	.....	100	100	....	Died	Died 5 days after thoracoplasty
Severe	Mod.	0	400 cc.	.....	0	.....	Easier	.....	No	No	No	101	100	98.6	Well	Well; chest clear by x-ray on Nov. 9, 1928
Mod.	Less	0	150 cc.	75 cc.	0	.....	Easier	.....	No	No	No	100	99	98.6	Well	X-ray checkup on Jan. 30, 1929, shows abscess healed; well and working on March 1, 1929
Severe	Less	Mod.	400 cc.	100 cc.	40 cc.	.....	Easier	No difference	Yes	No	Sl.	100	100	98.6	Improved	Last report March 1, feels much improved
Severe	Less	.....	800 cc.	200 cc.	.....	.....	.....	.....	.....	.....	.....	101	101	....	Died	Died 5 mo. later following operation by another surgeon
Severe	Temp. imp.	0	300 cc.	Temp. reduction to 40 cc. 3 wk.	0	.....	Easier	.....	Yes	Yes	Yes	99.4	100	98.6	Well	Gained 30 pounds; looks well, still has a small cavity not yet filled in; also bronchial fistula
Severe	Mod.	0	60 cc.	60 cc.	0	.....	Easier	.....	No	No	No	100	101	98.6	Improved	Lung condition has cleared up

4. In subacute and chronic pulmonary abscesses after rest in bed and postural drainage have been tried, I believe that temporary phrenicectomy will in selected cases allow the lung to relax enough to permit the cavity to contract and heal the lesion. It should receive more attention, in the treatment for pulmonary abscess, than is reported in the literature.

5. In cases of chronic pulmonary suppuration or suppurative pneumonitis, I do not expect a great deal of phrenicectomy alone, but feel that it is a valuable procedure to be combined with other surgical measures.

PAPILLOMAS OF THE CHOROID PLEXUS

REPORT OF TWO CASES, ONE WITH REMOVAL OF TUMOR AT OPERATION AND ONE WITH "SEEDING" OF THE TUMOR IN THE VENTRICULAR SYSTEM *

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Papillomas of the choroid plexus are a well known but relatively uncommon tumor in neuropathologic literature and much rarer still in surgical literature. Two cases of a true papilloma of the choroid plexus of the left lateral ventricle are here reported. In one the tumor was removed in toto at operation, and the other was encountered at autopsy. The latter is of especially great interest in that it represents an instance of "seeding" of this type of tumor throughout a portion of the ventricular system. Credence has not been given to "seeding" of papillomas of the choroid plexus, though there are several descriptive cases in the literature.

REPORT OF CASES

CASE 1 (J. S).—*Solid vascular tumor of inferior medial wall of left lateral ventricle in an infant, aged 3 months. Roentgen treatment following disclosure of tumor at operation; reduction in size of tumor; excision in toto at second stage operation. Pathologically a true papilloma of the choroid plexus.*

Clinical Record.—An infant, aged 3 months, was admitted to the surgical service on Sept. 3, 1928, because of bilateral internal squint and gradual enlargement of the head. The patient, a first child, was born at full term, weighing 8½ pounds (3.8 Kg.). There was nothing of note in the birth record except slight difficulty in getting the patient to breathe following a normal delivery. Vomiting occurred several times at the age of 5 or 6 days, and hypodermoclyses of saline solution were given because of dehydration. At the age of 2½ months a left internal squint was noticed which cleared up in a day or so and then recurred shortly after, with an internal squint on the opposite side. This persisted up to the time of admission. About two weeks prior to entry the head was noted to be enlarging, the veins of the scalp to be more prominent, and the fontanels to be bulging more than usual. Vomiting had occurred only once in this two week period, and feedings had been taken about as usual.

Physical Examination.—The patient was a well developed and well nourished active infant with a moderately enlarged head which measured 46 cm. in its greatest circumference and 30 cm. from the glabella to the external occipital protuberance. The fontanels were bulging moderately, and the veins of the scalp were fairly prominent. The only cranial nerve palsies noted were a bilateral abducens of moderate degree. The left arm and leg did not seem to be moved

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* From the Department of Surgery, the University of Rochester School of Medicine and Dentistry.

quite as much as the right though there was not any actual weakness noted. Deep reflexes on the left side were slightly increased over those on the right; neither observation was in keeping with subsequently disclosed conditions. On Oct. 1, 1928, the right ventricle was tapped and clear fluid under increased tension escaped. Twenty cubic centimeters of a 1 per cent solution of indigo carmine was introduced into the ventricle, and the left ventricle was tapped a few moments later. On tapping the left ventricle, highly xanthochromic fluid, also under tension, escaped but no trace of the dye was encountered. A lumbar puncture done about a half hour later showed that a faint trace of the dye had reached the lumbar sac. Results of examination of the fluids appear in the accompanying tabulation.

Operation.—On Oct. 3, 1928, under ether anesthesia a left-sided bone flap was turned down. The surface of the brain showed much flattening of the convolutions especially in the temporal region. An incision was made in the postparietal region through the thinned cortex extending into the distended ventricle. On the medial wall of the ventricle, about opposite the pineal gland region there was seen an irregular tumor mass 5 or 6 cm. in length and 4 or 5 cm. in height. The surface was grayish red. Around this tumor was a delicate envelope which was rather closely adherent to it. The tumor appeared on inspection to be too vascular for biopsy.

	Right Ventricle	Left Ventricle	Lumbar Sac Fluid
Pressure	Increased	Increased	Normal
Cells	0	Many old crenated red blood cells	0
Pandy reaction	+	+++	+
Total protein	225 mg.	2,062 mg.	240 mg.
Chlorides	720	708	768
Sugar	43.5	54	57
Specific gravity	1.012	1.015	Insufficient
Bile salts	0	0	0
Wassermann reaction	Negative	Negative	Negative
Guinea-pig inoculation	Negative	Negative	Insufficient

Consequently an opening about 1 cm. in diameter was made through the septum pellucidum to allow fluid to escape into the opposite ventricle. A small decompression in the left subtemporal region was made. The patient made an uneventful recovery from the operation and was discharged on the tenth postoperative day.

Roentgen Treatment.—The patient received deep roentgen treatments on Oct. 16 and Nov. 6, 1928, and on Jan. 15, 1929. There was moderate vomiting after each of these treatments.

Reentry.—On Feb. 6, 1929, the patient was readmitted because of the slowly increasing size of the head in spite of the roentgen treatment. Otherwise the patient had developed normally, and had gained steadily in weight and strength. The head measured 52 cm. in the greatest circumference, as compared with 46 cm. on previous admission. There were no cranial nerve or pyramidal tract palsies. A right homonymous heminopsia seemed certain from repeated examinations. The fontanels were under moderate tension.

Operation.—On Feb. 7, 1929, the left-sided craniotomy wound was reopened and the tumor exposed. There was at once apparent a striking change in its size and consistency. The tumor was firmer, appeared less vascular, and seemed to have decreased about 2 cm. in size in all dimensions. On dissection around the base it was found to be connected with the choroid plexus. Excision in toto was accomplished with the aid of the electrocautery. The patient made a

good recovery from operation, did not appear to have any pyramidal tract palsies and was again discharged on the tenth postoperative day.

Comment.—The anterior portion of the choroid plexus was left intact though it probably would have been better to have put a silver clip on its blood supply or to have excised it entirely.

Pathologic Examinations.—After hardening in a diluted solution of formaldehyde (10 per cent), the tumor measured 4.5 by 3 cm. (fig. 1). It was definitely delimited on all sides by a thin delicate membrane of glial tissue. On cut section the granular papillary structure of the tumor could be made out. Numerous minute cysts were encountered. Two fairly large arteries could be seen going into the tumor at its base where it was connected with the choroid plexus. Histologic examination of the tumor showed it to be a typical papilloma of the choroid plexus. Each section showed myriads of papillary projections most of

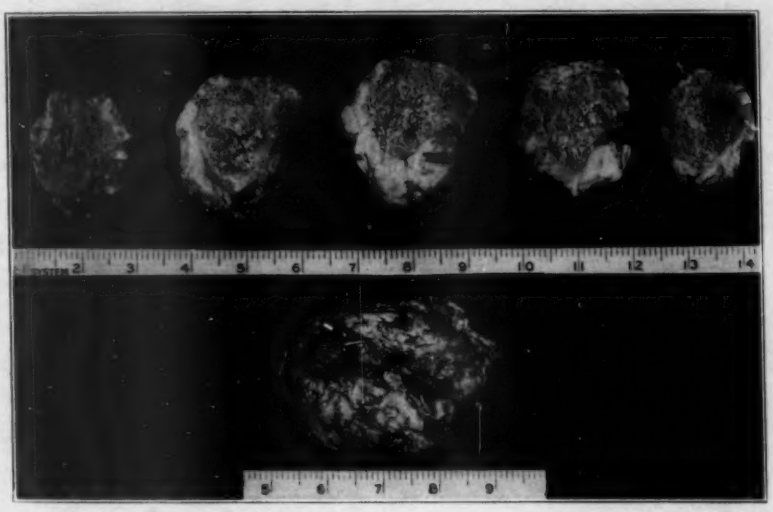

Fig. 1 (case 1).—Cut surfaces of tumor, papilloma of the choroid plexus and tumor in gross.

which had a connective tissue core, as demonstrated by van Gieson's and Perdrau's stains. The papillae were covered for the most part by a single layer of cuboidal or columnar epithelium. Pseudostratification occurred in some areas. No cilia could be seen, and blepharoplasten could be demonstrated by either Hortega's silver carbonate or Bailey's ethyl violet orange G stain. Glia fibers in the stroma of the tumor could not be made out (figs. 2 and 3). The diagnosis was papilloma of the choroid plexus of the left lateral ventricle.

Clinical Course.—Since discharge, now eight months ago, the patient has continued to improve. The head measures 49 cm. in its greatest circumference, as compared with 53 cm. before the second operation and 46 cm. before the first (fig. 4). There are no pyramidal tract palsies. A partial right homonymous hemianopia persists. Growth has continued normally.

CASE 2 (I. R.).—***Enormous papilloma of left choroid plexus, filling entire left lateral ventricle and third ventricle. Seeding of tumor in temporal horn of left ventricle and one implant in right lateral ventricle.***

Clinical Record.—The patient, a boy, aged 13, was admitted on the pediatric service in a critical state on June 25, 1927. He was suffering from headache, weakness of all extremities, aphasia, loss of weight, and pain and swelling in the region of the left knee joint. The father died at the age of 27, of pulmonary tuberculosis and tuberculous meningitis. The patient was exposed to infection from the father for eight years.

About fourteen months prior to admission the patient had an attack of "influenza" following which he tired easily. He became extremely "nervous," had trembling of the hands and feet, and found it increasingly difficult to walk or to handle objects. He continued to attend school until six months prior to entry. At this time his speech became markedly affected; he could not "get his words"

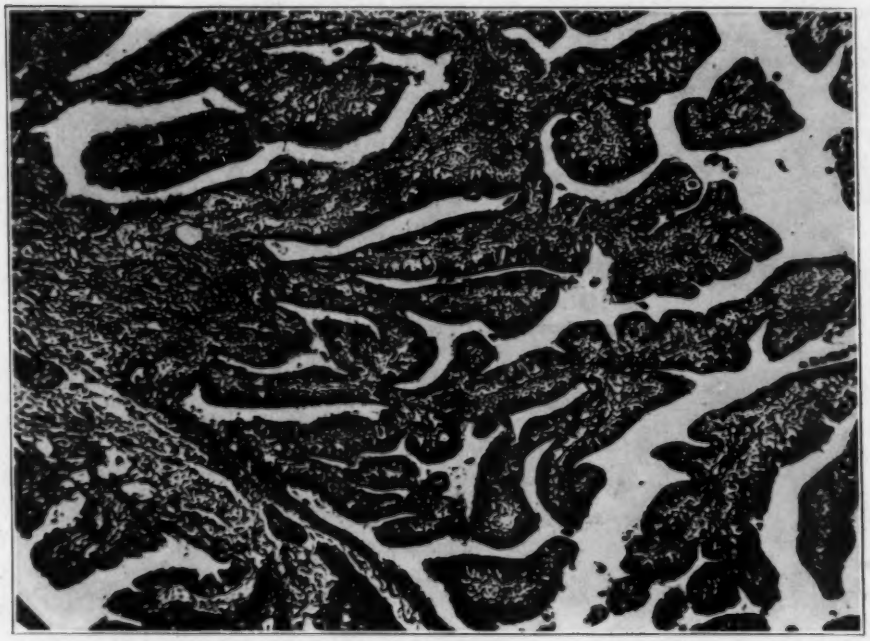

Fig. 2 (case 1).—Papilloma of the choroid plexus showing the general architecture of the tumor; phosphotungstic acid hematoxylin stain; reduced from × 150.

and was much confused. Headaches were severe. Three and a half months prior to entry he was confined to bed. He was observed in another hospital for three weeks where a polyuria as high as 3,900 cc. a day, with an average of from 2,400 to 2,700 cc. a day, was noted. A calcification to the left of the midline in the region of the pineal gland was demonstrated roentgenologically. Lumbar puncture showed a clear fluid "under tension," with 27 cells, globulin 3—. A diagnosis of tuberculous meningitis with polyuria was considered. In the interval between his stay at this hospital and admission to the Strong Memorial Hospital the course was progressively downward, with added complaints of painful swollen joints. After about three months at home he was admitted to the hospital.

Physical Examination.—On admission, the patient, who was tall and much emaciated, was unconscious most of the time and comprehended little of what was going on about him. There was a cracked pot sound on percussion of the skull. The neck was stiff, and there was a bilateral positive Kernig sign. The pupils were dilated and unequal, the right being larger, but both reacted slowly to light; there was a third nerve palsy on the left with external squint and nystagmus on looking to the right. The visual fields were impossible to map out. Ophthalmoscopic examination showed the veins to be tortuous and full and the disk margins hazy, without elevation of the disks. The optic cups were filled, and the picture was one of a residium of old choking of the disks. There was a right lower facial palsy; the gag reflex was absent and the pharynx muscles immobile. The tongue could not be protruded. All the deep reflexes were increased with a bilateral positive Babinski reflex; the ankle clonus varied from time to time. The superficial reflexes were absent. Roentgen examination showed a separation of the sutures, thinning of the bones, and a calcified shadow in the region of the pineal gland about 2 cm. to the left of the midline.

Fig. 3 (case 1).—Connective tissue framework of papilloma of the choroid plexus; Perdrau's connective tissue stain; × 620.

Clnical Pathology.—The urine was normal. The intake of fluid was from 1,200 to 1,500 cc. a day, but the output could not be accurately recorded, the patient being incontinent. The reaction to the tuberculin test was positive with 0.1 mg. human I. D. The spinal fluid was clear, colorless and under "moderately increased pressure." The cell count was 13 with 4 polymorphonuclear leukocytes and 9 lymphocytes. The spinal fluid showed sugar 77 mg. per hundred cubic centimeters, and globulin "definitely increased." The Wassermann reaction was

negative. The colloidal gold curve read 0000112211. The clinical course was steadily downward, and the patient died six days after admission.

Examination of the brain, which was fixed in a diluted solution of formaldehyde, showed the convolutions to be definitely flattened and widened with almost complete obliteration of the subarachnoid spaces, particularly on the left side. The whole left hemisphere was enlarged as compared with the right, and the median sulcus was seen to be deflected toward the right. On inspecting the base of the brain marked fulness was seen in the region of the pituitary and mammillary bodies, extending from the optic nerves back to the interpeduncular region. This was found to be a tumor which had extended into the third ventricle. It was covered by arachnoid and a thin film of glial tissue. The hypothalamic region was destroyed completely. The optic nerves were surrounded entirely. The

Fig. 4.—Patient in case 1, two months following an operation.

carotid arteries were pushed far to each side. The pituitary gland was removed for histologic study. In gross it appeared normal.

Beginning with frontal sections cut from the occipital pole forward, the first vestige of tumor was seen about 4 cm. from the tip of the occipital pole (figs. 5, 6, 7 and 8). This section showed a dilated ventricle on the right side and on the left a bit of tumor about 1 cm. long and 0.5 cm. wide. This was the posterior portion of a tumor which extended entirely through the left hemisphere to within 2 or 3 cm. of the frontal lobe. The tumor rapidly enlarged as it went forward, and sent finger-like processes short distances out into the brain substance, though everywhere these were sharply demarcated from the surrounding brain. There were areas in the tumor of a peculiar brownish, translucent, fairly firm substance which looked like hardened colloid. In the region of the anterior portion of the cerebral peduncles the tumor reached the size of 7 cm. in transverse and 6.5 cm. in vertical diameter. In this same section the third ventricle could be seen to be

dilated, pushed toward the right side and filled with tumor tissue. In the next section forward, the third ventricle was better seen. Here again it was entirely filled with tumor which extended down into the region of the infundibulum and was separated from the arachnoid and the pituitary stalk only by a very thin

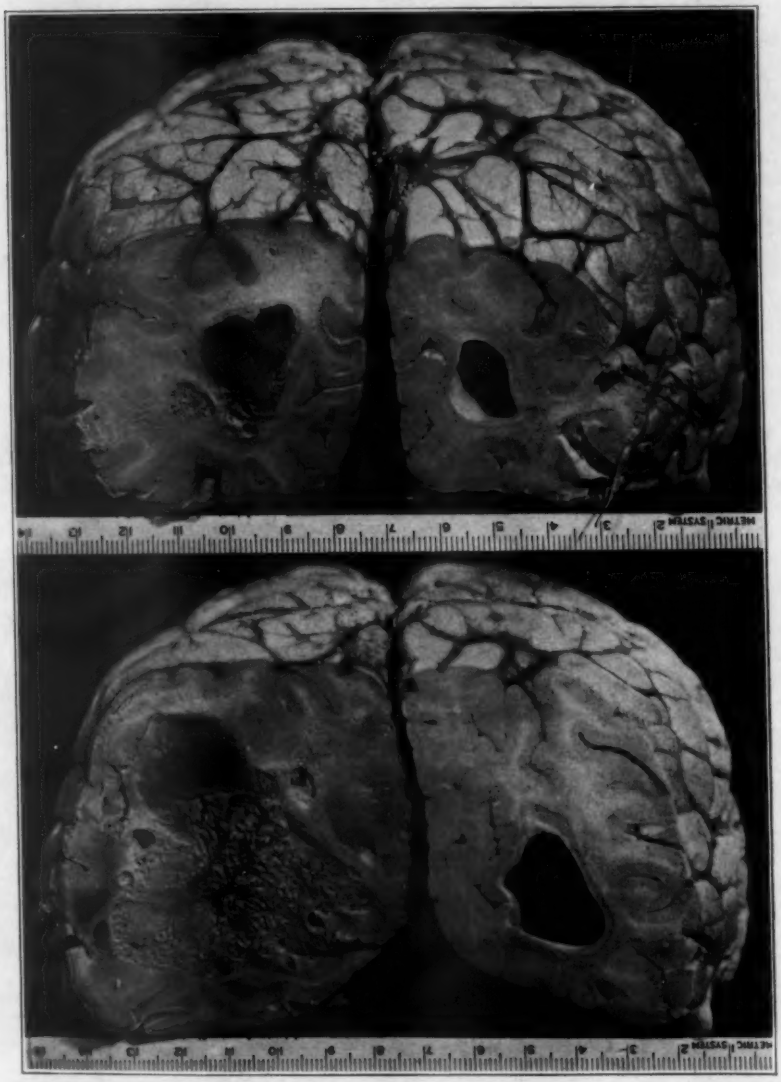

Fig. 5 (case 2).—Papilloma of the choroid plexus of left lateral and third ventricles; × 1.

shell of glial tissue. The left temporal horn was better seen in this section also. Its walls were studded with many small implants which had the same consistency as the tumor elsewhere. Direct implantation "seeding" seemed without doubt to have taken place. There was also a portion of the temporal horn wall that was

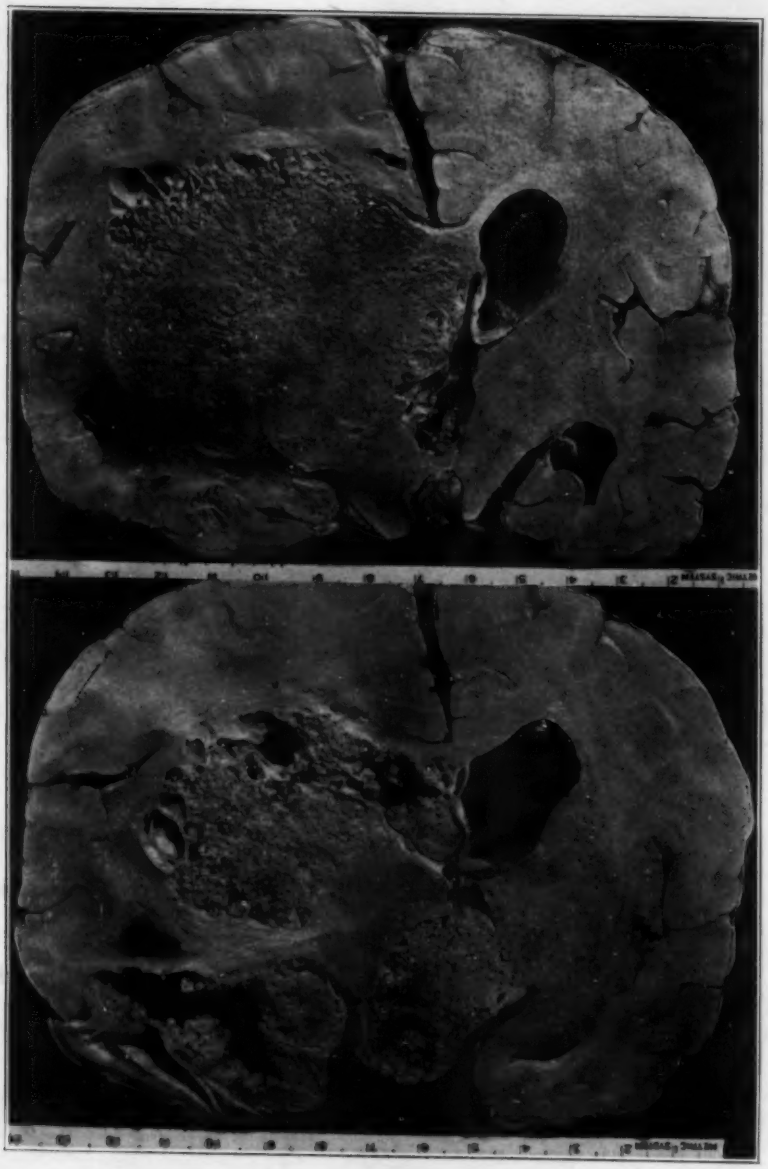

Fig. 6.—Sections of the papilloma shown in figure 5.

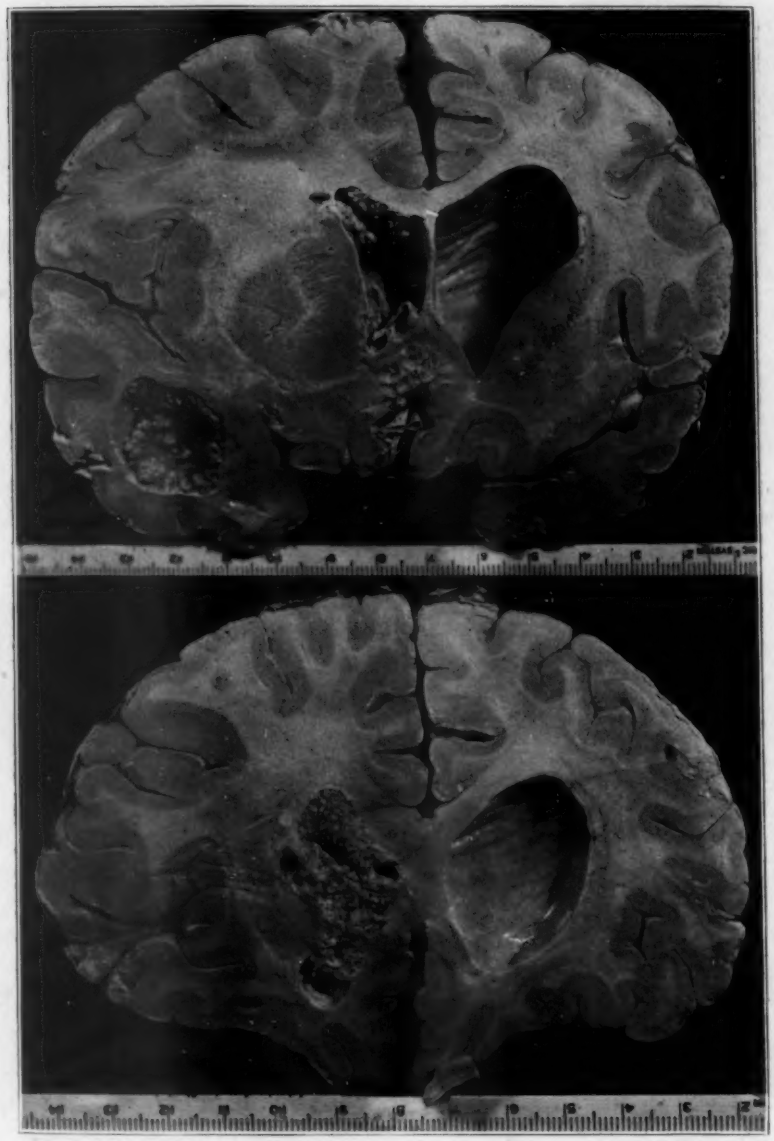

Fig. 7.—Sections of the papilloma shown in figure 5.

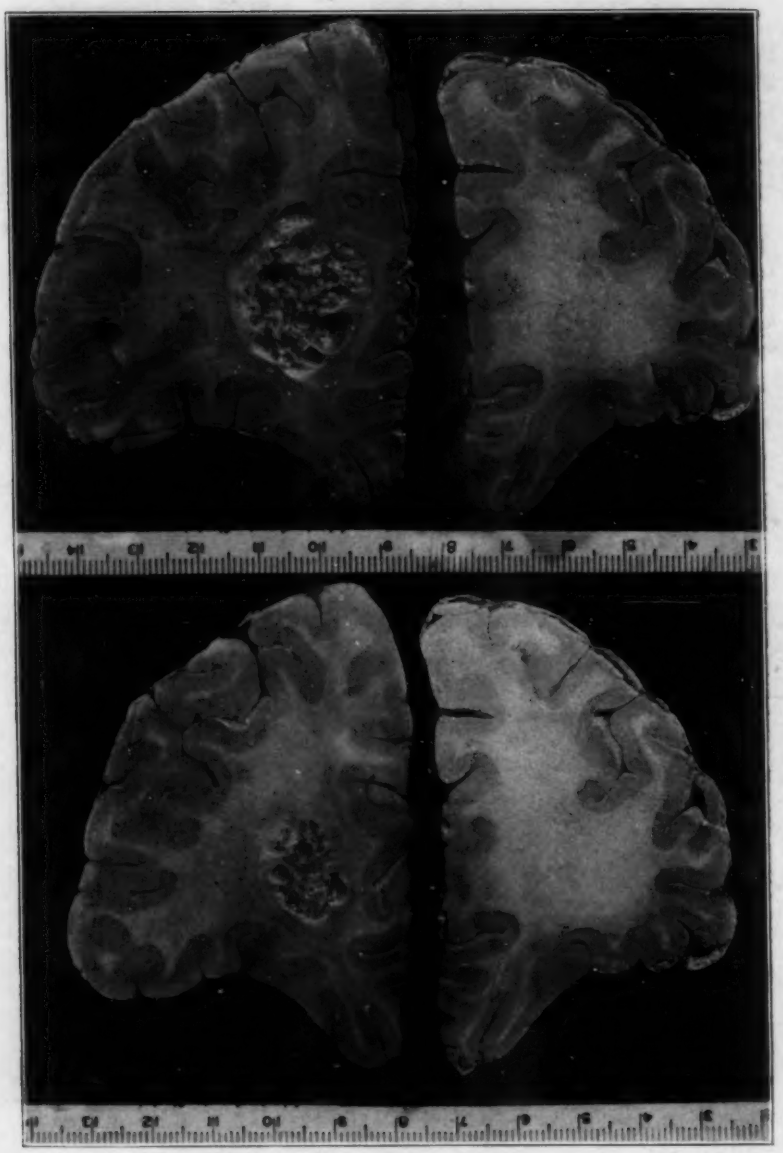

Fig. 8.—Sections of the papilloma shown in figure 5.

covered with tumor which had grown in by direct extension. This same growth by implantation was also seen in the left anterior horn which was not as completely filled with tumor, however, as was the posterior or the temporal horn. Vestiges of the choroid plexus itself could not be made out except for a short distance in the anterior horn. As stated before, the tumor extended forward to within 2 or 3 cm. of the left frontal pole. In the main it was granular; it seemed to have a central core in places which looked like fibrous connective tissue. There was an apparent papillary arrangement in the larger portions of the tumor. There were many small cysts varying from 1 to 3 or 4 mm. in diameter, with a few small necrotic zones. The choroid plexus on the opposite side appeared to be essentially normal. The opposite ventricle was much dilated. The fourth ventricle appeared

Fig. 9 (case 2).—Tumor of the choroid plexus implanted on wall of right lateral ventricle; reduced from × 3.

normal. The pituitary gland was entirely normal, both grossly and histologically. No evidences of the pineal gland could be made out.

In the opposite dilated occipital pole, entirely separate from any vestiges of the choroid plexus, there was a small raised papillary-like structure which was an implantation from the tumor of the opposite ventricle (figs. 9 and 10).

Microscopic Examination.—Blocks were taken from several parts of the tumor and showed the structure to be essentially the same everywhere. There were many papillae varying in size from short thick structures to long slender filaments some of which represent side branches from the papillae. The core was of connective tissue as demonstrated by van Gieson's and Perdrau's stains (fig. 11). The epithelium varied from low cuboidal to high columnar and was single-layered in nearly all instances. A few areas of pseudostratification were seen. Mitoses were

not made out. Blepharoplasten could not be demonstrated by either Hortega's silver carbonate or Bailey's ethyl violet orange G stain. Glial fibers could not be demonstrated in the core of the tumor. Numerous cysts were found in the tumor, all of which were formed by a colloid degeneration of the connective stroma of the papillae.

REVIEW OF THE LITERATURE

Mallory [1] has called attention to a method, based on earlier histologic studies of the ependyma, of accurate differentiation of ependymal from

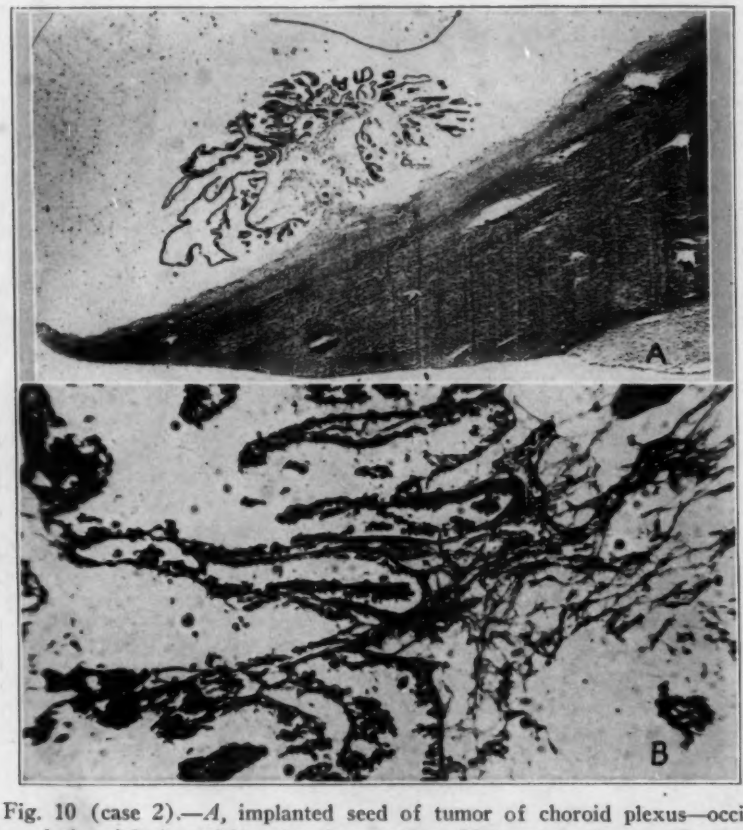

Fig. 10 (case 2).—*A*, implanted seed of tumor of choroid plexus—occipital horn of the right ventricle; phosphotungstic acid hematoxylin; × 15; *B*, connective tissue stroma in tumor implant; Perdrau's stain; × 620.

other gliomas by the presence of "Basalkörperchen" or "Blepharoplasten" in the cells of the former. These basal bodies do not occur in any other tumors of the nervous system except pinealomas. The same method therefore serves as an advantageous means of distinguishing papillomas of the choroid plexus from papillary ependymal tumors

1. Mallory, F. B.: Three Gliomata of Ependymal Origin, J. M. Research **3**:1, 1902.

and has been so employed by Saxer,[2] Bielschowsky and Unger,[3] Sjövall,[4] Davis and Cushing[5] and others. Another equally valuable means of distinguishing papillomas of the choroid plexus is by their connective tissue framework. Whether this is abundant or scanty, it can readily be distinguished by suitable means, such as the connective tissue stain of Perdrau or van Gieson, from the glia structure forming the framework of ependymomas. Then, too, the epithelium of plexus tumors abounds in coarse granular often conglomerate mitochondria compared with the scanty minute mitochondrial bodies of ependymomas.

Fig. 11 (case 2).—Papilloma of the choroid plexus showing the architecture of the tumor and the connective tissue stroma; Perdrau's connective tissue stain; × 150.

It has generally been considered that plexus tumors are not "seeded" by the cerebrospinal fluid, while it is not an infrequent occurrence in

2. Saxer, F.: Ependymepithel, Gliome und epitheliale Geschwülste des Centralnerven systems, Zeiglers Beitr. z. path. Anat. **32**:276, 1902.

3. Bielschowsky, Max; and Unger, Ernst: Zur Kenntnis der primären Epithelgeschwulste der Adergeflechte des Gehirns, Arch. f. klin. Chir. **81**:61, 1902.

4. Sjövall, Einar: Ueber une Ependymcyste embryonalen charakters (Paraphyse?) im dritten Hirnventrikel mit todlichen Ausgang, Beitr. z. path. Anat. u. z. allg. Pathol. **47**:248, 1909.

5. Davis, L. E., and Cushing, Harvey: Papillomas of the Choroid Plexus with a Report of Six Cases, Arch. Neurol. & Psychiat. **13**:681 (June) 1925.

ependymal tumors. However, there would seem to be considerable evidence that this manner of spread does occur. LeBlanc,[6] in 1868, reported a tumor of the left lateral ventricle "the size of child's fist," with two small well delimited implants in the subpial tissues of the right cortex. All were of identical macroscopic appearance. From the sketch there can be little doubt but that the growth was a papilloma of the choroid plexus (fig. 12). Bielschowsky and Unger [3] also reported a tumor which arose in the region of the right flocculus of the cerebellum, with about fourteen implants over the surface of the cortex; all were identical with the original tumor. From the description and illustrations it would seem reasonably certain that they are derived from

Fig. 12 (case of LeBlanc).—Papilloma of the left lateral ventricle. (From Beitr. z. path. Anat. d. Gehirn Tumoren, Inaug. Dissert., Bonn, 1868.)

a papilloma of the choroid plexus of the fourth ventricle. Von Bouwdijk [7] has recorded a probable though not certain case which is also an example of this (fig. 20). There was a cystic tumor of the cerebellum, with seeding of countless tumors in the subarachnoid spaces. The tumor structure of the original growth was a papillomatous one made up of cores of connective tissue covered with high columnar nonciliated epithelium. The smaller tumors were all of a similar nature. Autopsy did not reveal any other tumor in the body from which

6. LeBlanc, Christian: Papillom Myxomatodes, Beitr. z. path. Anat. d. Gehirn Tumoren; Inaug. Dissert., Bonn, 1868.

7. Von Bouwdijk, Bastiaanse: Primäres metastasierender Gehirncarcinom, Ztschr. f. d. ges. Neurol. u. Psychiat. **27**:96, 1914.

metastases could have occurred. It is hardly conceivable that the original tumor was a hidden carcinoma metastasizing to subarachnoid spaces alone. Neither does the tumor appear to be an instance of "sarcomatosis of the leptomeninges" recently reviewed by Bailey.[8] The case of Beneke[9] may possibly be another example. Töppich[10] has described a papillomatous tumor of the choroid plexus of the fourth ventricle with numerous seedings in the subarachnoid space over the cerebrum and cerebellum and also about the spinal cord. He considered that the original tumor was carcinomatous because of invasion of the cerebellum. Such a phenomenon as this, however, is not conclusive evidence of true

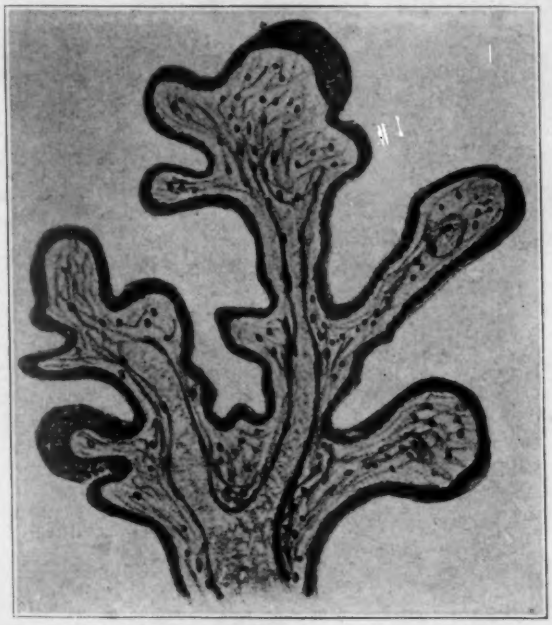

Fig. 13 (case of Ribberts).—Papilloma of the fourth ventricle. (From Geschwerstlehre, 1904.)

malignancy, and has been observed by Cushing and others. Pushing of papillae of the tumor between the leaflets of the cerebellar cortex is to be more truly looked on as the direct result of pressure. Gromelski[11]

8. Bailey, Percival: Intracranial Sarcomatous Tumors of Leptomeningeal Origin, Arch. Surg. **18**:1359 (April) 1929.

9. Beneke, R.: Casuistische Beitrage zur Geschwulstlehre, Virchows Arch. f. path. Anat. **119**:60, 1890.

10. Töppich, G.: Die Zottenkrebse des Adergeflechte der Rautengrube, Frankfurt. Ztschr. f. Path. **33**:238, 1925.

11. Gromelski, Alfred: Beitrag zu der Lehre von den primären epithelialen Geschwülsten des Zentral nerven Systems, Virchows Arch. f. path. Anat. **261**: 933, 1926.

reported a curious papillary epithelial tumor with a connective tissue core found in the lumbar region of the spinal canal. His description of the brain was not adequate to show whether this had its origin from a tumor of the choroid plexus by seeding or whether it arose from an embryologic rest as the author assumed.

In case 2 here reported, the left temporal horn is studded with hundreds of minute tumors which are identical macroscopically and

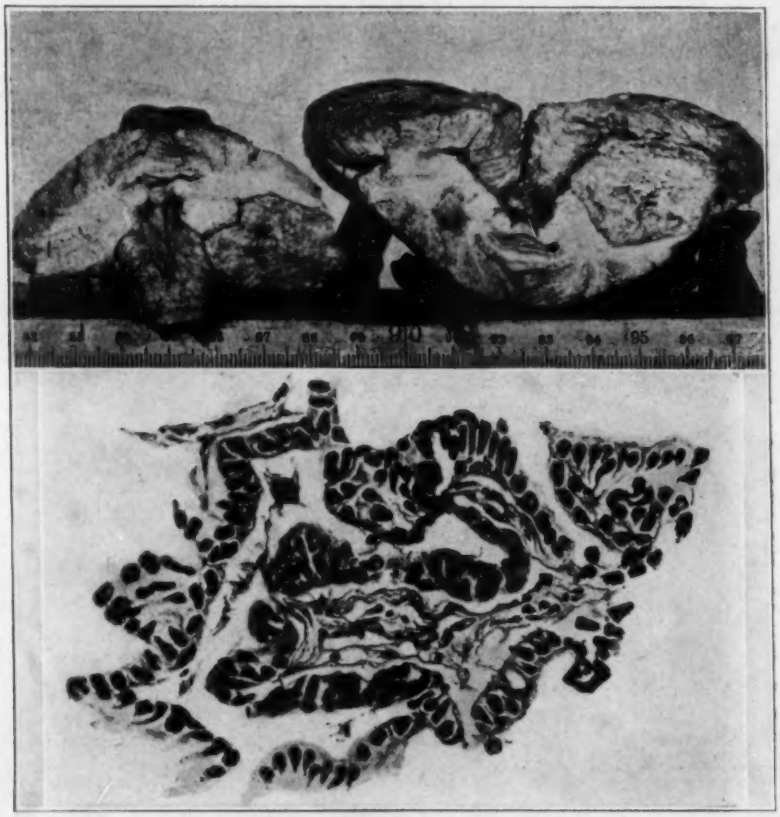

Fig. 14 (case of Bielschowsky and Unger).—Papilloma of the fourth ventricle. (From Arch. f. klin. Chir. **81**:61, 1906.)

microscopically with the original tumor and which are quite apart from it. The implant in the dilated right lateral ventricle is well away from the original growth and represents a true tumor implantation, both macroscopically and microscopically (fig. 9). The smaller nodules are epithelial only in character, while the larger lateral ventricle transplant has a scanty connective tissue core (fig. 10*A*). Seeding of tumors adjoining the cerebrospinal fluid spaces cannot be looked on as evidence

of malignancy of the tumor but is probably an accidental occurrence in which trauma may well play a considerable part.

Tumors of the choroid plexus of the lateral ventricle are particularly apt to have an enveloping membrane about them. This membrane may be closely applied to the surface of the tumor as in case 1 or separated from it by fluid which has been poured out by the tumor cells. Occasionally this process goes on to such an extent that it leaves the tumor

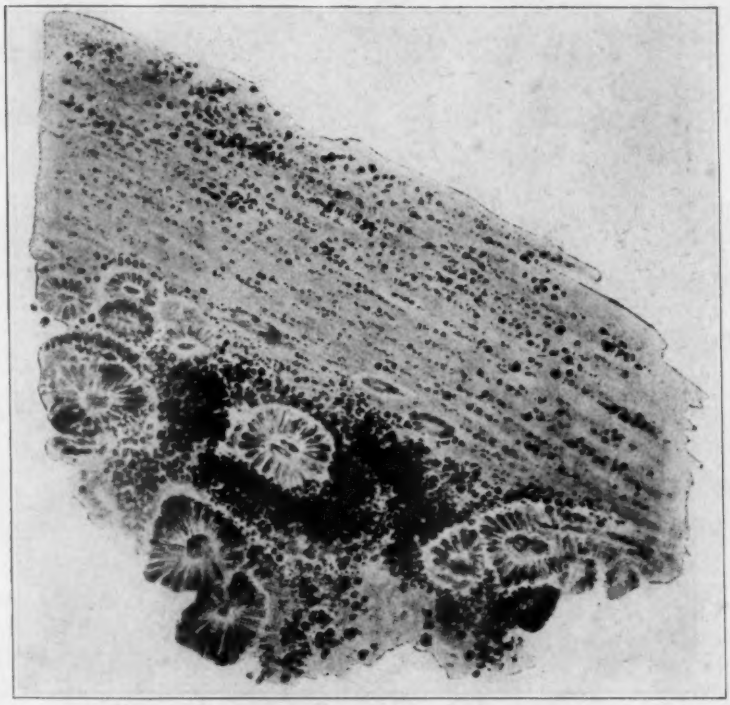

Fig. 15.—Section of papilloma shown in figure 14.

like a nodule in a cyst wall. A few such blood vessel tumors undoubtedly tend to be self-destructive in this manner.

Another distinguishing feature of plexus tumors is their benign nature and lack of invasive tendencies. Papillae occasionally push their way for a short distance into brain substance in which softening from contiguous pressure has occurred, or between leaflets of the cerebellar cortex.

There are in the literature a few reports of papillary tumors of the choroid plexus which, because of their invasive tendencies, merit the term, carcinoma. The most notable examples are the cases of Rokitan-

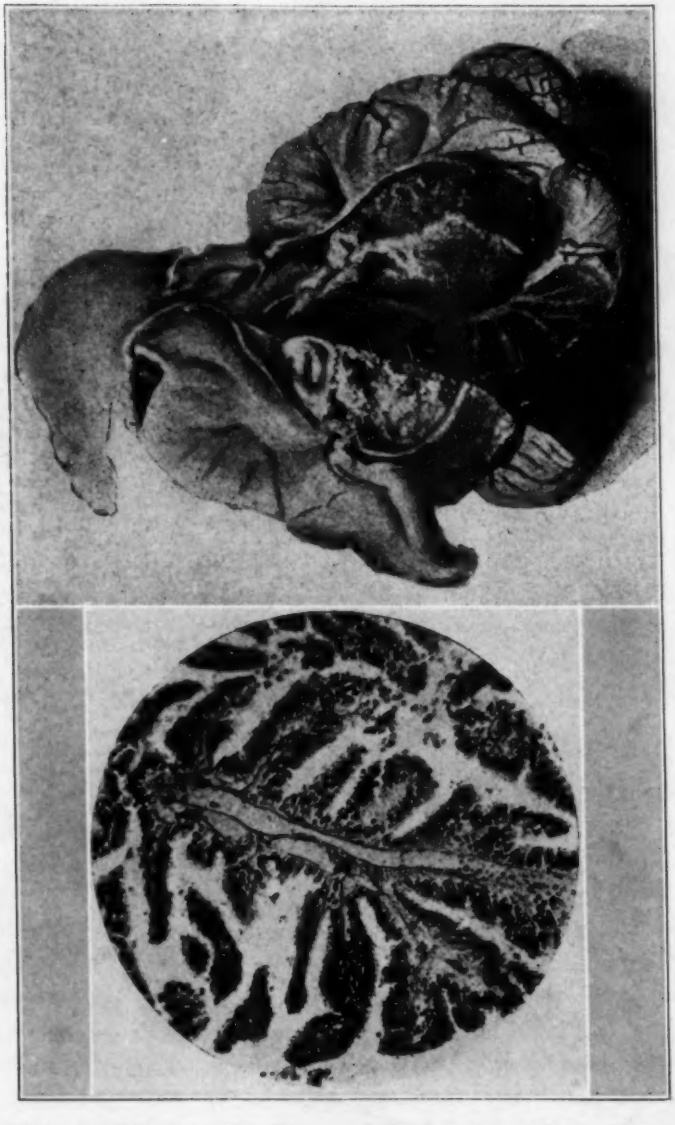

Fig. 16 (case of Rheindorf).—Tumor of the fourth ventricle. (From Charité Ann. **32**:294, 1908.)

sky,[12] Spaet,[13] Körner [14] (case 1) and Kölpin.[15] The most adequately described and illustrated case of carcinoma of the choroid plexus in the literature is that of Lehoczky.[16] The case of Esser [17] seems very doubtful and is more likely a benign papilloma of the plexus that has pushed into adjoining tissue space.

Cysts of the Choroid Plexus.—In going over the literature on the tumors of the choroid plexus, i. e., papillomas, carcinomas, endotheliomas, lipomas, sarcomas, chondromas, etc., one is struck with the fact that the great majority of cysts are associated with the papillomas. In the main they tend to occur where epithelial growth has outstripped its blood supply. With the exception of one type the cysts seem to have been formed primarily at the expense of the connective tissue, and vestiges of epithelium can be found covering the cyst wall or near its base. Sjövall [4] reported a case in which the cyst was connected with

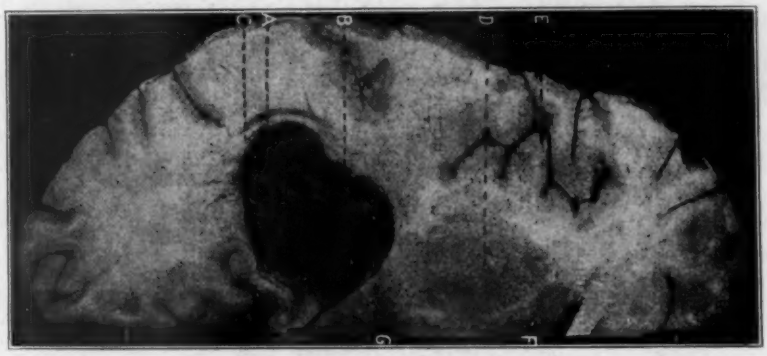

Fig. 17 (case of Boudet and Clunet).—Papilloma of the right lateral ventricle. (From Arch. de méd. expér. et d'anat. path. **22**:379, 1910.)

the choroid plexus of the third ventricle and lined with epithelium of an embryonic ependymal ciliated nature. Typical blepharoplasten were found in the cells.

Calcification, as noted in case 2, represents deposits of lime salt in old hemorrhagic areas and not about blood vessels as described by van Dessel in gliomas of the brain. My case 2, the case of Robin and

12. Rokitansky, Carl: Lehrbuch. d. path. Anat. 3., 1856, vol. 2, p. 425.

13. Spaet: Primärer Multipler Epithelkrebs des Gehirns, Aertzl. Intelligenzbl. **30**:305, 1883.

14. Körner, Hildegard: Geschwülste der Adergeflechte, Zentralbl. f. allg. Pathol. u. path. Anat. **30**:121, 1919.

15. Kölpin: Multiple Papillome (Adeno-Carcinome) des Gehirns, Arch. f. Psychiat. **45**:595, 1909.

16. Lehoczky, T.: Zur Frage der Primären Gehirn carcinome, Arch. f. Psychiat. **82**:527, 1928.

17. Esser, A.: Ein Carcinom des Plexus chorioideus des IV Ventrikels, Ztschr. f. d. ges. Neurol. u. Psychiat. **106**:511, 1906.

Blondel [18] and that of Lüttgen [19] seem to be the only instances in which calcification has been reported in this type of tumor.

The most common location for these tumors is in the fourth ventricle, the second in the lateral ventricles and the least common in the third ventricle. Of the forty-seven cases here assembled twenty-three were in the fourth ventricle, seventeen in the lateral ventricles and six in the third ventricles. It is a curious coincidence that of all the reported papillomas of the lateral ventricles 93 per cent are of the left side.

Cushing's series of verified tumors furnishes about the only available information as to incidence. He reports six true cases among 964 verified tumors, or 0.6 per cent.

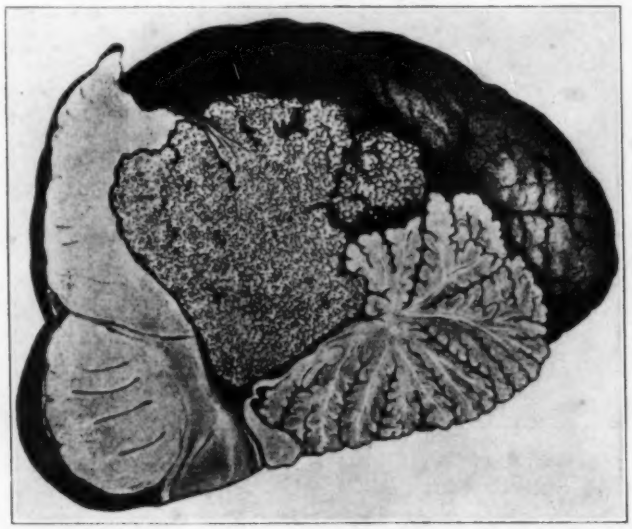

Fig. 18 (case of Vonwiller).—Papilloma of the fourth ventricle. (From Virchows Arch. f. path. Anat. **204**:230, 1911.)

Simple symmetrical or regional hypertrophy of the choroid plexus does occur. A notable example is that reported by Cushing. Hydrocephalus was assumed to have arisen from an increased production of fluid. The question as to where simple hypertrophy ends and papillomatous tumor formation begins is an academic one. The case reported by von

18. Robin and Blondel. Description d'une tumeur épithéloid provenant du plexus choroide dont elle garde a la structure fondamentale, Gaz. méd. de Paris **32**:7 and 506, 1858.

19. Lüttgen, Paul: Ueber ein Fall von Papillom des Plexus chorioideus, Inaug. Dissert., Wurzburg, 1896.

Plath [20] is that of a local hypertrophy of the choroid plexus, with hydrocephalus presumably from excessive formation of fluid.

The age incidence for these tumors is a gradually diminishing one. In thirty-five cases in which the age is given, there were nine cases in the first decade, seven in the second, five in the third, four in the fourth, five in the fifth and three in the sixth.

SURGICAL EXPERIENCES

The first surgical attempt made toward removal of one of these tumors is reported in the case of Bielschowsky and Unger. The cases

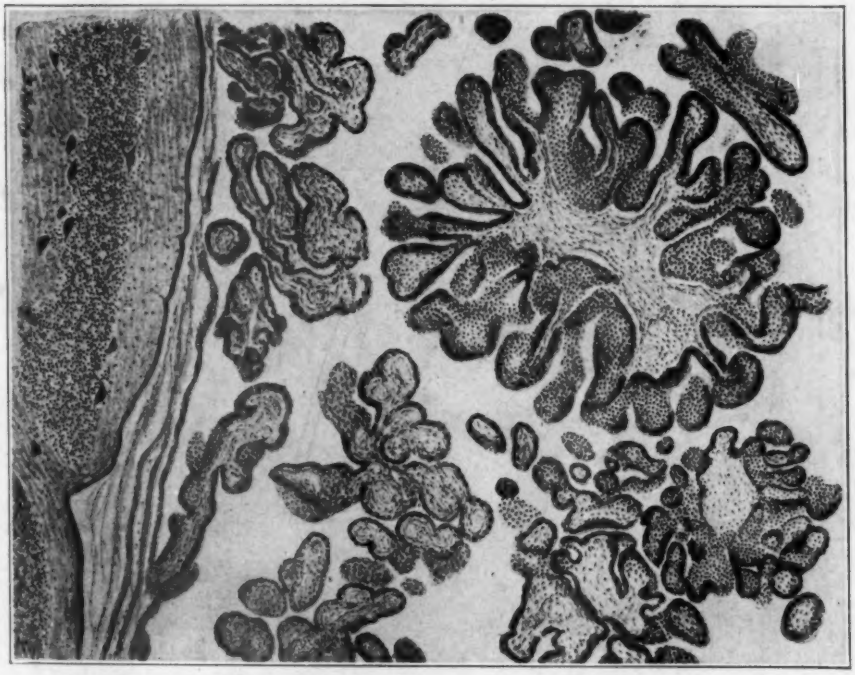

Fig. 19 (case of Natonek).—Papilloma of the fourth ventricle. (From Virchows Arch. f. path. Anat. **218**:170, 1914.)

in which operative procedures have been undertaken are listed as follows:

Observer	No. of Cases	Outcome
Bielschowsky and Unger.....	One	Fatality
Bouwdijk.....	One	Fatality
Perthes.....	One	Recovery
Sachs.....	One	Recovery
Cushing.....	Two	Fatality
	One	Patient lived for 3 months
	Two	Patients were living and well 1 year later
	One	Patient was living and well 18 months later
Van Wagenen.....	One	Patient was living and well 8 months later

20. Von Plath: Hyperplasie der plexus choroideus laterales bei hydrocephalus internus congenitus, Jahrb. f. Kinderh. **21**:417, 1884.

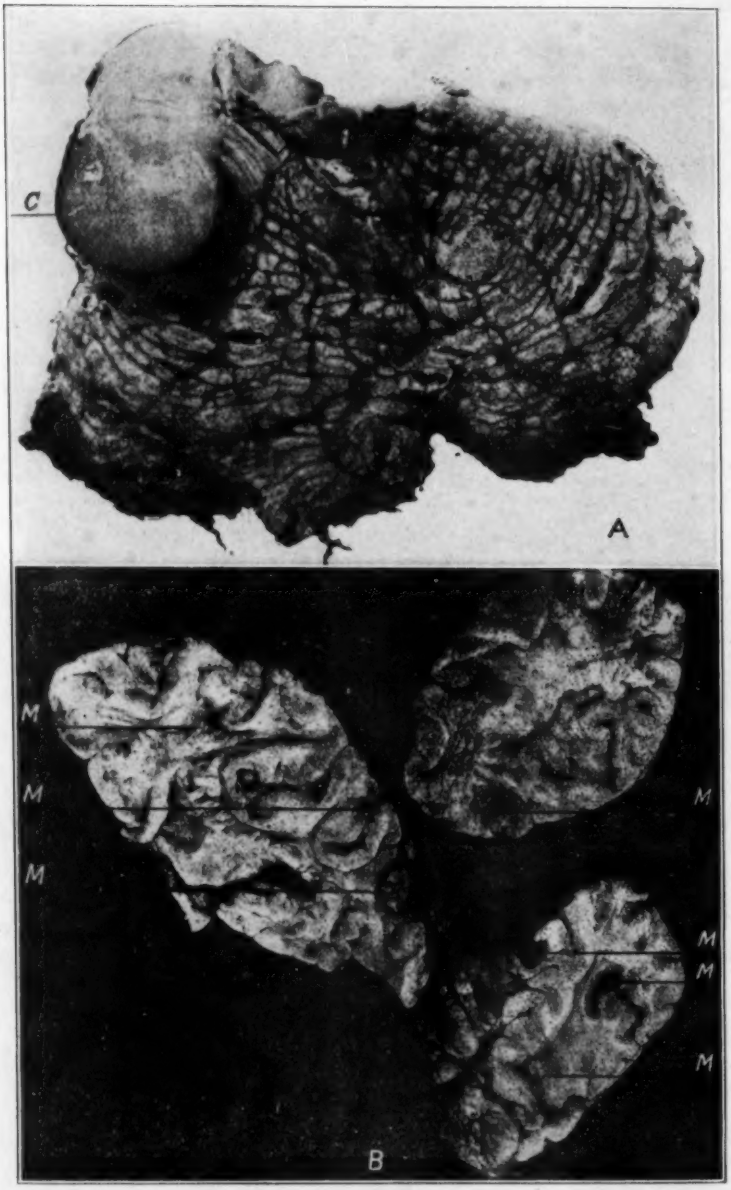

Fig. 20 (case of Bouwidjk).—*A*, cystic tumor of the cerebellum; *B*, sites of subarachnoidal tumor transplants. (From Ztschr. f. d. ges. Neurol. u. Psychiat. **27**:96, 1914.)

CASES REPORTED IN THE LITERATURE

CASE 1 (Guerard[21]).—In a patient, aged 3, autopsy revealed a tumor of the posterior end of the right lateral ventricle the size of a hen's egg, which was lobulated and enclosed in a thin membrane. The tumor was in contact with the choroid plexus, was granular on section, very vascular, and made up of small blood vessels and epithelial elements.

CASE 2 (Robin and Blondel[18]).—In a patient, aged 11, a tumor, 6 by 4 by 3 cm. was found lying free in the fourth ventricle. The tumor was made up of papillary-like growths closely resembling the normal structure of the choroid plexus and replacing the normal plexus structure. One or more layers of epithelium were found covering the papillae. Calcareous particles were found occasionally.

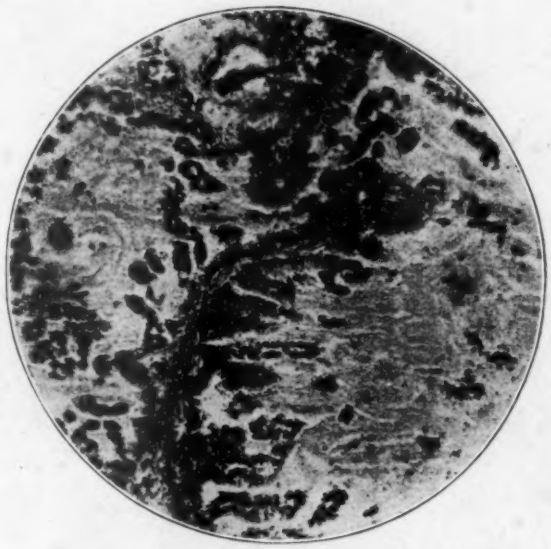

Fig. 21 (case of Bouwidjk).—Microscopic section of tumor making up part of wall of cyst. (From Ztschr. f. d. ges. Neurol. u. Psychiat. **27**:96, 1914.)

CASE 3 (Levrat-Perroton[22]).—In a patient, aged 25, a fourth ventricle tumor the size of a nut was attached to the choroid plexus from which it arose. The tumor compressed the cerebellum but was separated from it, penetrated the aqueduct of Sylvius and separated the cerebral peduncles. It was gelantinous, transparent, of colloid consistency and covered by epithelial cells. The center of the tumor was made up of amorphous material, with connective tissue strands bearing blood vessels subdividing it here and there.

CASE 4 (LeBlanc,[8] case 1).—In a patient, aged 60, an original tumor the size of a child's fist was found on the floor of the left lateral ventricle. Two small tumors the size of a pear-seed were also found partly buried in the tissues of the surface of the right cortex but in connection with the subarachnoid space. These

21. Guerard: Tumeur fonguèse dans le ventricule droit du cerveau chez une petite fille de trois ans, Bull. Soc. anat. de Paris **8**:211, 1832-1833.

22. Levrat-Perroton, Francois: Thèse de Paris, 1869.

nodules lay at the entrance of the small vessels of the pia into the cortex of the brain. Macroscopically and microscopically all these tumors were alike. The large tumor was made of a central core of blood vessels which branched out into delicate papillae. The papillae were covered with cylindric epithelium. There were no cilia (fig. 12).

Case 5 (Kelly[23]).—In a patient, aged 11, autopsy disclosed a tumor of the fourth ventricle, 1 by 1½ inches (2.5 by 3.8 cm.) in size, which distended the ventricle and appeared at the base at the left of the medulla. The tumor had a granular surface, was irregular in shape, yellowish red, and was made up of a vast number of delicate villous tufts, each equipped with a thin-walled vessel and

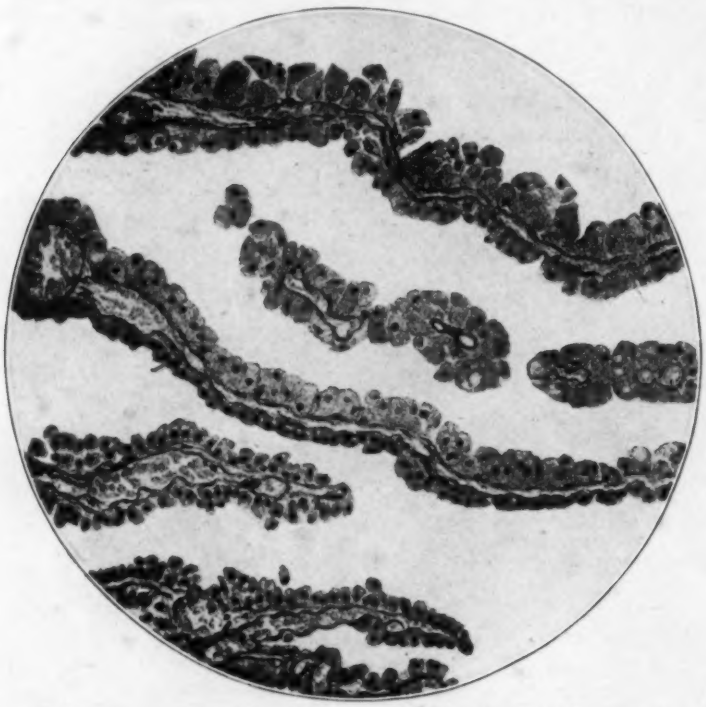

Fig. 22 (case 2 of Körner).—Papilloma of the right lateral ventricle. (From Centralbl. f. allg. Pathol. u. path. Anat. **30**:121, 1919.)

covered with columnar epithelium. "It seemed to have grown from the choroid plexus." (This case has come down in the literature as that of Dr. Garrod under whose hospital care the patient was.)

Case 6 (Chouppe[24]).—In a patient, aged 42, a tumor of the fourth ventricle arising from the choroid plexus and compressing the cerebellum was uncovered at autopsy. The tumor consisted of a light connective tissue framework bearing large capillaries and covered with epithelium.

23. Kelly, Charles: Papilloma of the Fourth Ventricle, Tr. Path. Soc. London **24**:6, 1873.

24. Chouppe: Étude sur les tumeurs du quatrième ventricle, Verron, Thèse de Paris, 1874.

CASE 7 (Demange[25]).—A tumor the size of a nut was found in the left lateral ventricle of a patient aged 8. It was pedunculated and attached to the choroid plexus and formed by a heaping up of the choroid plexus. There was an accompanying chronic hydrocephalus.

CASE 8 (von Plath[20]).—The patient, aged 3, was considered to have died of congenital hydrocephalus. The ependyma of the ventricles was smooth and

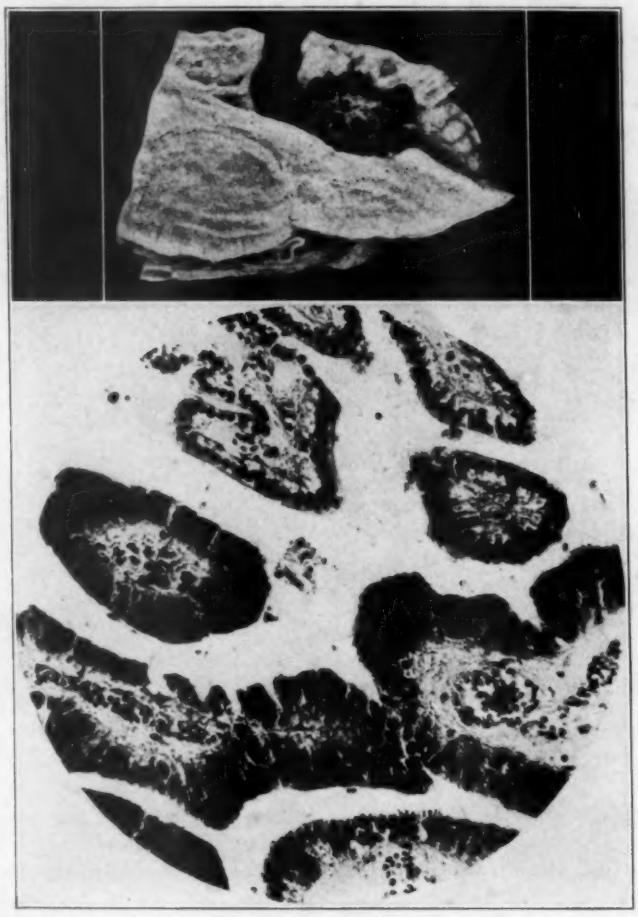

Fig. 23 (case of Priesel).—Papilloma of the fourth ventricle. (From Virchows Arch. f. path. Anat. **253**:125, 1924.)

glistening. The choroid plexus of both ventricles was very thin from the foramen of Monro to the beginning of the posterior horn where it thickened out on both sides to the size of a walnut and then tapered off again. The author con-

25. Demange, E.: Paraplegia incomplete: scarlatine: albuminurie; symptoms d'urémie à l'autopsie; hydrocéphale ventriculaire, Bull. Soc. anat. de Paris **49**:503, 1924.

sidered that overproduction of cerebrospinal fluid by the tumorous plexuses might have been the cause of the hydrocephalus.

Case 9 (Audry,[26] case 1).—Autopsy on a patient, aged 45, disclosed a tumor of the left ventricle the size of a small nut. The tumor was spongy, friable, attached to the choroid plexus, covered with a fibrous capsule and made up of connective tissue and blood vessels. The cells resting on the blood vessels were granular, with round or oval nuclei.

Case 10 (Douty[27]).—In a patient aged 17, autopsy revealed a large tumor, the size of a bantam's egg, free in the fourth ventricle. It was attached to the roof of the ventricle by two delicate strands of membranous connective tissue conveying blood vessels. The tumor was mulberry-like, friable, gelatinous, non-invading, villous and "agrees in structure with the fringes of the choroid plexuses of the ventricles."

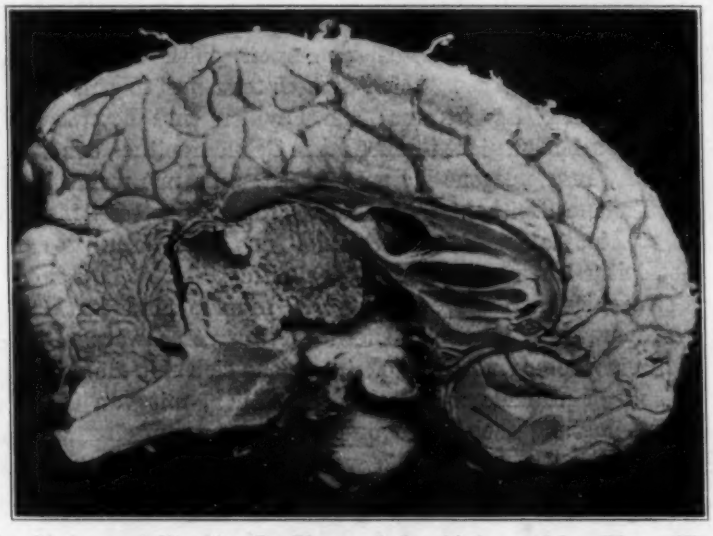

Fig. 24 (case of Noodt).—Papilloma of the third ventricle. (From Virchows Arch. f. path. Anat. **258**:331, 1925.)

Case 11 (Beneke,[9] case 2).—In a patient aged 26, a tumor of the third ventricle was found at the entrance of the infundibulum. It was grayish red, soft, mulberry-like and rather loose from the ependyma which was everywhere lightly granular. The pineal gland was normal.

In the cavity of the fourth ventricle lay a tumor, 4 by 2 by 2.5 cm., which compressed the pons and medulla and was connected with the brain stem only by loose tissue filaments. The cerebellum was more firmly connected with the tumor in the region of the anterior vermis. "Microscopically the tumor is a typical papilloma whose short, knitted, filamentous forms have a relationship with the embryonal growth formations of ependymal filaments, for example the choroid plexus."

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26. Audry, J.: Les tumeurs des plexus choroïdes, Rev. de méd. **11**:897, 1886.

27. Douty, J. Harrison: Notes and Remarks upon a Case of Villous Tumor in the Fourth Ventricle, Brain **8**:409, 1885-1886.

Case 12 (Stroeber,[28] case *b*).—Autopsy on a patient, aged 1 year and 6 months, revealed a tumor of the left ventricle the size of a walnut. Tumor also filled the temporal horn but did not invade brain substance. Microscopically the appearance was that of the choroid plexus.

Case 13 (Hess[29]).—In a patient aged 31, a tumor composed of two parts was found in the fourth ventricle at autopsy; the smaller part measured 1 by 1.5 cm., and the larger 1.5 by 2.5 cm. The tumor was cauliflower-like and reddish gray; it compressed the pons medulla and cerebellum but did not invade it. Microscopically it proved to be a papillary growth made up of blood vessel cores covered with epithelial cells.

Case 14 (Luttgen[29]).—A tumor of the third ventricle, the size of a pigeon's egg, was found at autopsy. The tumor was connected with the choroid plexus

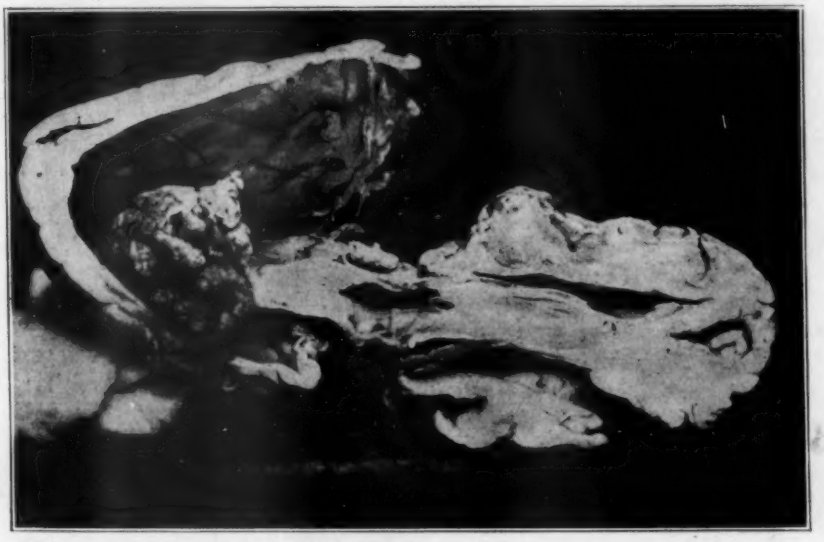

Fig. 25 (case of Noodt).—Papilloma of the left lateral ventricle. (From Virchows Arch. f. path. Anat. **258**:331, 1925.)

and was made up of papillae of varying sizes and breadths. The papillae were covered with cylindrical epithelium. There were calcareous concretions in the tumor.

Case 15 (Auvray[30]).—A tumor of the fourth ventricle was found which was about 4 by 5 cm. in size, and of the form of a large chestnut. Microscopically it was made up of well filled capillaries with immature endothelium and a loose structure of round and even cells set together which appeared like a growth of plexus epithelium.

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28. Stroeber, H.: Papillom des Plexus chorioideus im linken Seitenventrikel, Berl. klin. Wchnschr. **30**:123, 1893.

29. Hess, Freidrich: Beitrage zur Geschwulstlehre, Inaug. Dissert., Bonn, 1896.

30. Auvray: Tumor des plexus chorioideus des Fourth Ventricles, Centralbl. f. allg. Pathol. u. path. Anat. **9**:275, 1898.

CASE 16 (Bruchanow[31]).—In the left "cella media" there was found a tumor, 5 cm. in diameter, which was connected with the choroid plexus. It showed an exquisite papillary structure. The whole tumor resembled a normal choroid plexus. The epithelium was low cylindric.

CASE 17 (Henneberg[32]).—A walnut-sized, hard, uneven tumor was found at autopsy in connection with the choroid plexus of the third ventricle. The distal end of the tumor reached through the iter into the fourth ventricle. The tumor showed a papillary structure. The epithelium about the connective tissue structures bearing the blood vessel was high cuboidal.

CASE 18 (Ribberts[33]).—A tumor of the fourth ventricle was found. Figure 13 shows it to be typical of a choroidal plexus papilloma.

CASE 19 (Bielschowsky and Unger[3]).—Autopsy on a patient, aged 43, showed a tumor arising in the region of the right flocculus of the cerebellum with about fourteen identical smaller tumors scattered over the surface of both hemispheres. The symptoms produced by one of these tumors over the left cortex led to a craniotomy at which time a portion of the tumor was removed. Reoperation at the same site three months later proved fatal.

All of the tumors were sharply separated from the surrounding brain and all were in direct connection with the subarachnoid space, with one possible exception. This one subcortical tumor lay along a blood vessel dipping down into the brain, and the tumor arose on the blood vessel as if on a pedicle. There were also two small tumors found at the base in the region of the sixth nerves.

Microscopically the tumor proved to be composed of epithelium which rested on blood vessels and was arranged radially about the lumen of the vessel (fig. 14).

Comment: This would seem to be a probable example of a papilloma of the plexus of the fourth ventricle which spread by "seeding" in the cerebrospinal fluid system.

CASE 20 (Vigouroux[34]).—At autopsy the fourth ventricle was found filled with a tumor the size of a nut, arising from the choroid plexus. All the ventricles were dilated.

CASE 21 (Rheindorf[35]).—Tumor of the fourth ventricle, 4 by 2.5 cm., with a true papillary structure and connected with the choroid plexus (fig. 16) was found in a patient aged 21.

CASE 22 (Slaymaker and Elias[36]).—A tumor of the fourth ventricle, 4.2 by 4 by 5.2 cm., was found at autopsy in a patient aged 11. It filled the entire ventricle and projected downward between the cerebellum and the medulla. The tumor was directly continuous with the choroid plexus which appeared to be

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31. Bruchanow, N.: Ueber einen Fall von Papillom des Plexus chorioideus ventriculi lateralis sinister bei einem 2½ Jahrigen Knaben, Prag. med. Wchnschr. **23**:585, 1898.

32. Henneberg: Ueber einen Fall von Papillärer Geschwulst des Plexus chorioideus in dritten ventricle, Berl. klin. Wchnschr. **12**:277, 1903.

33. Ribberts, Hugo: Geschwerlstlehre, Bonn, Friedrich Cohen, 1904, p. 359.

34. Vigouroux, A.: Écoulement de liquide céphalo-rachidien: hydrocéphalie papillome des plexus choroides du quartrième ventricle, Rev. neurol. **26**:281, 1908.

35. Rheindorf: Papillares Epitheliom des fierte Ventricules, Charité-Ann. **32**:294, 1908.

36. Slaymaker, S. R., and Elias, F.: Papilloma of Choroid Plexus with Hydrocephalus, Arch. Int. Med. **3**:289 (May) 1909; Chicago Path. Soc. **7**:187, 1907-1909.

larger than normal. Microscopically there were "slender stalk-shaped villous branching and greatly tangled frameworks of connective tissue covered with columnar epithelium arranged for the most part in a single layer."

CASE 23 (Boudet and Clunet,[37] case 1).—At autopsy on a patient, aged 45, there was found a tumor, 3 or 4 cm. in size, situated in brain substance but continuous with the choroid plexus on the right side. The lateral ventricle was obliterated and the tumor curved downward into the temporal horn of the ventricle. The tumor consisted of two parts: an internal cystic and cavernous portion and a covering papillomatous portion. The papillae of the latter were formed by vascular connective tissue covered with cuboidal epithelium which reproduced the structure of the normal plexus. The tumor had invaded the nerve tissue in places, and deep in the brain were strands of epithelial cells which probably represented a pushing out of papillae into softened brain substance (fig. 17).

CASE 24 (Vonwiller[38]).—A tumor, 3.5 by 3 cm., lying free in the fourth ventricle and not invading any of the surrounding structures was found at autopsy on a patient aged 15½ years. The tumor arose by a pedicle from the region of the obex. It was a papillary growth made up of a stroma of blood vessels and connective tissue which was covered by epithelium. The whole structure was considered to resemble closely normal choroid plexus. No cilia were found on the epithelium (fig. 18).

CASE 25 (Natonek[39]).—A walnut-sized tumor filling the fourth ventricle and lateral recesses was found at the medial side of the flocculus. Microscopic examination showed a tumor with many long and some short filamentous processes. The epithelium covering the filaments was in single rows for the most part. Most but not all of the papillae had a central blood vessel (fig. 19).

CASE 26 (von Bouwdijk[7]).—In a patient aged 57, symptoms referable to a tumor of the cerebellum had led to an operation being performed in that region. A solid papillomatous tumor was removed. Death occurred a few hours later. At autopsy another tumor of the posterior fossa was found, which was circumscribed, nut-sized and gelatinous, with an uneven surface. The tumor rested on the surface of the cerebellum, stood out from it somewhat and was but little connected with its surrounding tissues. Grossly, no other nodules were noted in the cerebellum. After fixation in a diluted solution of formaldehyde, a number of tiny nodules were seen in the subarachnoid spaces over both hemispheres. All rested superficially and in connection with the subarachnoid space. Almost all were single, gelatinous, rather hard and whitish gray. There were none in the gray matter or the basal ganglions. In a careful autopsy no source for a primary tumor was found elsewhere. The larger tumor in the cerebellum was a cystic one which raised itself above the surface of the brain. When the cyst was opened, a papillary tumor was found to make up a part of its inner wall.

Microscopic examination showed the cyst wall of the primary tumor to be made up of a covering of connective tissue which was poor in cells. The solid

37. Boudet, C., and Clunet, S.: Contribution a l'étude des tumerus épithéliales primitives de l'encéphale, développées aux dépues des formations épendymaires et particulièrement des plexus choroïdes, Arch. de méd. expér. et d'anat. path. **22**:379, 1910.

38. Vonwiller, Paul: Ueber das Epithel und die Geschwulste der Hirnkammern, Virchows Arch. f. path. Anat. **204**:230, 1911.

39. Natonek, Desider: Zur Kenntnis der primaren epithelialen Tumoren des Gehirns, Virchows Arch. f. path. Anat. **218**:170, 1914.

nodule in the cyst wall was composed of papillae with a connective tissue stroma rich in blood vessels. The papillae were covered by a layer of high cylindric epithelium. Nowhere were cilia to be seen. No glia fibers were found.

The metastases were in part cystic. Microscopically they proved to have the same papillary structure as the tumor described (fig. 20 *B*).

Case 27 (Weygandt[40]).—Autopsy on a patient, aged 10 months, revealed a tumor of the left ventricle, 7.3 by 8 cm. in size, which showed a papillary structure and which was definitely connected with the choroid plexus. Microscopically the cells had an outspoken epithelial character with giant cells here and there containing 2 or 3 nuclei. The blood vessels were abundant and thin-walled, with hemorrhages into the tumor.

Case 28 (Goodhard[41]).—In a patient, aged 6 months, a tumor of the right lateral ventricle, 4 by 3.5 by 3.5 cm., attached to the choroid plexus was found at autopsy. It was firm and reddish purple, and nowhere did it invade the brain. It was composed of a number of papillomatous processes containing a central capillary and covered with a single layer of short columnar epithelium. There was a hydrocephalus of all ventricles considered by the author to be due to an excessive formation of fluid.

Case 29 (Körner[15]).—Autopsy on a patient aged 9 revealed a tumor, 8.5 by 5 cm. in size, in the right lateral ventricle. Microscopically it was a typical papilloma of the choroid plexus (fig. 22).

Case 30 (Perthes[42]).—In a patient aged 47, a large left-sided tumor arising from the choroid plexus and extending to the surface of the brain in the occipital region was surgically extirpated. The tumor showed a papillary structure and was partly cystic. The papillae were made up of blood vessels covered with large epithelial cells.

Case 31 (Lorenzini[43]).—In a patient aged 10 years, a tumor the size of a hen's egg was found in the third ventricle extending from the anterior pillars of the trigone to the posterior white commissure. It was connected at its base with the choroid plexus. The tumor was partly cystic and filled with yellowish fluid as were also the lateral ventricles. The external surface of the tumor was irregular and nodular. The solid portion of the tumor had a papillary structure made up of epithelial cells in one or more layers. There were numerous small cysts in the solid portion of the tumor. It was everywhere sharply demarcated from nerve tissue.

Case 32 (Sachs[44]).—In a patient aged 55, a well incapsulated tumor which filled the fourth ventricle and extended into the aqueduct of Sylvius was surgically extirpated. A microscopic study did not accompany the report, but Cushing reports that a later examination proved the tumor to be a true papilloma of the choroid plexus.

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40. Weygandt: Hydrozephalus mit Tumor (Papillom des Plexus chorioideus), Deutsche med. Wchnschr. **43**:797, 1917.

41. Goodhard, G. W.: Adenoma of the Choroid Plexus, Guy's Hosp. Rep. **69**:217, 1918.

42. Perthes: Gluckliche Entfernung eines Tumors des Plexus choriodeus aus dem Seitenventrikel des Cerebrum, München. med. Wchnschr. **66**:677, 1919.

43. Lorenzini, Aldo: Papilloma cistico del terzo ventricolo, Riv. di clin. pediat. **20**:705, 1922.

44. Sachs, Ernest: Papilloma of the Fourth Ventricle: Report of a Case, Arch. Neurol. & Psychiat. **8**:379 (Oct.) 1922.

CASE 33 (Priesel[45]).—A chance observation at autopsy on a patient, aged 74, was a tumor of the fourth ventricle, 1.5 by 1.2 by 1 cm. in size, that was definitely connected with the choroid plexus. Vessels could be seen entering the tumor from the plexus. It arose from the region of the calamus scriptorius. Microscopic examination showed it to be composed of many broad papillae with a fine framework of blood vessels bearing connective tissue. Cuboidal and columnar epithelium covered the papillae. Many of the epithelial cells contained pigment (fig. 23).

CASE 34 (Okabe[46]).—At autopsy on a patient, aged 5 months, a tumor of the third ventricle was found arising from the choroid plexus. The tumor extended into the lateral ventricles. A microscopic report is not given.

CASE 35 (Noodt[47] case 1).—Autopsy on a patient, aged 33, revealed a tumor 5 by 3 cm. occupying the third and lateral ventricles and the aqueduct of Sylvius. It bordered anteriorly on the septum pellucidum and the fornix, above on the corpus callosum and behind on the splenium, the recessus pinealis and the stria medullaris, the posterior commissure, and underneath on the thalamus. A small part of the tumor lies in the sylvian aqueduct. The growth was cystic in its posterior portion. Microscopically the stroma was made up of connective tissue which was rich in blood vessels but poor in cellular elements. The papillae of the tumor were covered in part with a single-layered, high, nonciliated, cylindric epithelium in part with a cuboidal epithelium of more than one layer. The picture was that of "a papillary epithelioma of the choroid plexus." It was not, the author said, of pineal gland origin (fig. 24).

CASE 36 (Noodt[47] case 2).—An irregular lobulated tumor of the left lateral ventricle, 6 by 4 by 4 cm., was found at autopsy on a patient aged 1. The tumor was made up of very small papillae rich in blood vessels and containing little connective tissue stroma. The papillae were covered with a high, single-layered cylindric epithelium (fig. 25).

CASE 37 (Davis and Cushing[5] case 1).—In a patient aged 22, a tumor of the fourth ventricle, approximately 5.5 cm. in diameter, was removed through an incision in the left cerebellar hemisphere. Microscopically the tumor "showed a papillomatous structure comprised of numerous cauliflower-like villi, which had a central core of loose fibrous connective tissue. The epithelial cells covering the villi were cuboidal in shape and were arranged in one layer. . . . The cells did not contain 'blepharoplasten' and glia fibers were not present."

CASE 38 (Davis and Cushing,[5] case 2).—Autopsy on a patient, aged 9, revealed a tumor of the left lateral ventricle surrounded by a number of smooth lined cysts. "The villi were arranged in a somewhat compact fashion, and only in places showed typical papillomatous characteristics. They consisted of a very small central core of loose white connective tissue, in which were situated blood vessels. Each villus was clothed by a single layer of cuboidal cells."

CASE 39 (Davis and Cushing,[5] case 3).—At operation on a patient, aged 50, a fragment of tumor was removed for microscopic study. It proved to be a part of a papillomatous growth. "The villi were long and narrow, and exhibited many side branches. Blepharoplasten and glia fibers were absent." The tumor was in the left hemisphere.

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45. Priesel, A.: Ein Beitrag zur Kenntnis der Tumoren der Plexus Chorioidei, Virchows Arch. f. path. Anat. **253**:125, 1924.

46. Okabe, Yoitsu: A Case of Papilloma of the Plexus Chorioideus in a Child, Gann **18**:28, 1924.

47. Noodt, Klara: Ein Beitrag zur Kenntnis der Papillaren epitheliome des Plexus chorioideus, Virchows Arch. f. path. Anat. **258**:331, 1925.

CASE 40 (Davis and Cushing,[8] case 4).—At operation on a patient, aged 30, a fragment of tumor was removed from an incision in the right cerebellar hemisphere. On microscopic examination it showed "numerous villi which were somewhat larger than normal and much more numerous. They had a characteristic cauliflower appearance. The central core of each villus consisted of loose white fibrous connective tissue containing numerous blood vessels. The epithelial cells covering these villi were cuboidal in shape and arranged in a single layer."

CASE 41 (Davis and Cushing,[8] case 5).—A portion of a very vascular tumor was removed from an incision through the vermis of the cerebellum in a patient aged 27. "It had the characteristic papillomatous structure which identified it as having originated from the choroid plexus. The villi were numerous, long, wide and possessed many side branches. The central core consisted of a dense, white, fibrous connective tissue with blood vessels. The epithelial cells were cuboidal in shape, and the cytoplasm was finely granular."

CASE 42 (Davis and Cushing,[8] case 6).—In a patient aged 28, a tumor, approximately 4.5 cm. in diameter, was surgically removed through an incision in the vermis of the cerebellum. "Microscopically sections revealed the typical papillomatous appearance, with villi much larger than those encountered in a normal choroid plexus. The central core contained very little white fibrous tissue, being made up for the most part of loose reticular tissue. There were numerous blood vessels with very thin walls. The epithelial cells were tall and columnar with oval or cylindrical centrally placed nuclei."

CASE 43 (Töppich[20]).—Autopsy on a patient, aged 2, revealed a tumor completely filling the fourth ventricle. There were also numerous secondary nodules in the subarachnoid spaces of the basilar systems, about the cerebellum and in the lower part of the spinal canal. The tumor arising from the choroid plexus was composed of a papillae made up of epithelial cells, mostly high columnar, resting on a connective tissue framework. Blood vessels were abundant in the connective tissue spaces. The original tumor had pushed its way into the cerebellum near the fastigium.

CASE 44 (Zalka[48]).—A tumor of the fourth ventricle compressing pons and medulla and cerebellum was found at autopsy. It was made up of blood vessels and connective tissue arranged in papillary form covered with cylindric epithelium. The structure was considered to be typical of choroidal plexus.

CASE 45 (Grandclement[49]).—Autopsy disclosed a cauliflower-like tumor, the size of a nut, in the left cerebellopontile angle. Microscopically the tumor was made up of delicate, sharply outlined growths of connective tissue containing blood vessels covered with epithelium in regular simple rows. "It resembles neoplasms of the choroid plexus."

SUMMARY

1. Two cases of papilloma of the choroid plexus are reported. In one the tumor was surgically removed from the left lateral ventricle with relief from symptoms. The second case represents the observation at

48. Zalka, Edmund: Histologische Veranderunger des Plexus chorioideus bei verschiedenen Krankheitsfornen, Virchows Arch. f. path. Anat. **267**:398 and 412, 1928.

49. Grandclement, A.: Tumeurs des plexus choroïdes du quatrième ventricle, Lyon méd. **140**:136, 1927.

necropsy of a huge papilloma of the choroid plexus with true "seeding" of the tumor via the cerebrospinal fluid.

2. The reports of about forty-five cases have been collected from the literature which, so far as one can determine from the descriptions given, seem to have arisen from the choroid plexus. A few of these presented the phenomenon of "seeding."

3. The favorite site for these tumors is the fourth ventricle; 50 per cent were so situated; 34.7 per cent were in the lateral ventricles, and 17.3 per cent in the third ventricle. By some curious coincidence 93 per cent of tumors of the lateral ventricle have been on the left side.

4. The age incidence was greatest in the first decade and gradually diminished up to the sixth decade.

5. The surgical removal of this type of tumor is feasible, especially with the aid of electrosurgical devices. Preliminary roentgen treatment in my cases appeared to have reduced the vascularity greatly.

6. A considerable part of the nonobstructive hydrocephalus found with tumors of the choroid plexus may well be associated with the increased epithelial surface.

SPONTANEOUS RUPTURE OF THE NORMAL SPLEEN *

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Spontaneous rupture of the normal spleen or of the apparently normal spleen is a rare condition. A search of the literature reveals only eight cases. Of these, six may be considered authoritative and two doubtful.

CASES FROM THE LITERATURE

Shorten [1] reported one case in 1919.

CASE 1.—A man, aged 43, entered the hospital with the complaint of vomiting and severe abdominal pain about the umbilicus. The onset was sudden, six hours previously. A year and a half before this time, he had been buried in the trenches after which he had developed severe abdominal pain and had been sent to the hospital for three months. The pain had not returned after his discharge. Other than this his previous health had been good.

At the time of entrance, examination showed extreme abdominal pain and tenderness, no change in liver dulness, but signs of free fluid in the abdomen. At operation, fluid and clotted blood were found in the peritoneal cavity. The spleen was found nonadherent and bleeding from a rent in the capsule. The gallbladder contained many small stones but was left intact.

The spleen was dissected almost into two equal parts by the hemorrhage, the tear extending transversely from the convex surface to the hilum. There had been no stripping of the capsule. The absence of adhesions and scars, or stripping of the capsule, made it seem unlikely that the previous injury was responsible for the rupture.

The patient's recovery was uneventful.

One case was reported by Connors [2] in 1921.

CASE 2.—A man, aged 38, an alcoholic, had bronchitis and was suspected of having pulmonary tuberculosis. For three months previous to his admission to the hospital he had nausea, constipation and pain in the right upper part of the abdomen. No injury had been sustained, and he had never had typhoid or malarial fever. At the time of entrance to the hospital, he complained of pain in the upper part of the left side of the abdomen.

Roentgen examination showed a stricture of the colon at the splenic flexure which was thought to be malignant. No stricture of the colon was found at operation. The spleen had a hematoma beneath the capsule and was removed. There was no active bleeding at the time of removal. Examination of the spleen showed the splenic tissue to be apparently normal. Except for the hematoma which practically bisected the spleen longitudinally, it was normal in size. No microscopic examination was made.

The patient recovered from the operation, but three months later returned to the hospital with pain in the upper part of the abdomen, and examination disclosed

* Submitted for publication, Sept. 3, 1929.

1. Shorten, W. W.: Brit. M. J. **2**:844, 1919.
2. Connors, J. F.: Ann. Surg. **74**:1, 1921.

a tumor mass in the upper part of the left side of the abdomen which proved to be a cyst, probably of the pancreas, resulting from the inclusion of a part of the tail in the ligature. Four years later, the patient died of pulmonary tuberculosis.

In 1922, Metcalfe and Fletcher [3] reported two cases.

CASE 3.—A man, aged 21, developed a sudden severe pain in the left side of the abdomen, radiating to his left shoulder; he vomited and went into a state of shock. Several hours later, he developed paroxysmal pain in the left upper quadrant, accompanied by tenderness, but no rigidity or distention. He had a leukocyte count of 25,000. No history could be obtained of an injury, or of malarial or typhoid fever. He had had influenza and pneumonia a few years previously. He had had no gastric symptoms, and the Wassermann reaction was negative.

Splenectomy was performed, and the patient recovered. The spleen was apparently normal microscopically and macroscopically.

CASE 4.—A man, aged 21, developed cramplike abdominal pain that radiated to the left shoulder, and dizziness. This pain came on following a large drink of cold water. On admission to the hospital, he said that he had had no previous serious injury or illness. The day after admission, he got out of bed but had a return of the abdominal pain and dizziness. He later developed more pain, shock and signs of internal hemorrhage. At this time, there was no rigidity or distention, but dulness was present in the flanks. The following day, he still had pain in the abdomen and shoulder and seemed in a little better condition. The dulness in the flanks had increased, however, and at operation blood was found in the peritoneal cavity. A clot was found about the spleen, and splenectomy was performed.

The spleen was found to have ruptured on the convex surface, but microscopically and macroscopically it was otherwise normal. Recovery followed.

The fifth case was reported by Susman [4] in 1927.

CASE 5.—A man, aged 53, seventeen hours before admission developed a sudden severe pain in the upper part of the abdomen as he bent down to lift a bucket of water, and became nauseated. He had previously been in good health until the last three months, during which he had flatulence and indigestion after meals. There was no history of typhoid, malaria or injury.

On examination, the patient appeared to be in a state of shock. The abdomen was boardlike, distended and very tender in the upper and left portions. The liver dulness was decreased, and he had pain in the right shoulder as well as in the abdomen. A preoperative diagnosis of perforated peptic ulcer was made.

At operation the transverse colon was so greatly distended that puncture was necessary before exploration could be made. The pelvis contained blood that was seen to be coming from the spleen, which was removed. About 10 or 12 ounces (2.95 or 3.55 cm.) was present in the peritoneal cavity, but at the time of operation there was no active bleeding. The patient died three days after operation from paralytic ileus.

"The spleen was normal in size, shape and consistency; there was a hematoma almost as big as the spleen itself, beneath the capsule on the convex surface, where there was a tear about 1½ inches long and ½ inch deep, transverse and midway between the upper and lower poles. The spleen was carefully dissected

3. Metcalfe, R. F., and Fletcher, L. Z.: Ann. Surg. **75**:186, 1922.
4. Susman, M. P.: Brit. J. Surg. **15**:47, 1927.

in a search for some abnormality but none was found." Examination of the other organs showed them to be normal.

The sixth case was reported by Rhame [5] in 1928.

CASE 6.—A white man, aged 25, an electrician, was seized with a sudden sharp pain in the left upper part of the abdomen, just after finishing dinner. He vomited almost at once. Despite two purgatives, the bowels had not moved at 4 the next morning. He had had influenza seven years before but no other illness. No history of malaria, typhoid or injury was given.

At the time of entrance to the hospital, he showed mild shock, moderate distention of the abdomen, tenderness under the left costal margin and rigidity over the entire left side of the abdomen. Pressure over any part of the abdomen caused pain in the left upper quadrant. There was no pain in the shoulder. Analysis of the blood showed: hemoglobin, 85 per cent; leukocytes, 13,040, and polymorphonuclear neutrophils, 85 per cent.

At operation about 750 cc. of free blood was found in the abdomen, including clots. A rent was found in the outer surface of the spleen. Splenectomy was performed. The patient has remained well, with a practically normal blood picture.

Examination of the spleen showed it to be normal in size and appearance except for a tear in the capsule about the middle of the convex surface. The hemorrhage extended through the middle of the organ toward the root. Microscopically, the pulp was normal. The malphigian bodies were thickened. At one point the veins contained a beginning thrombus, but there was no reason to suppose that this thrombus antedated the hemorrhage.

The next two cases described may be regarded as doubtful. In 1874, Atkinson [6] described a case.

CASE 7.—A woman, aged 35, had complained of epigastric pain and vomiting for five months. She developed severe pain in the left upper part of the abdomen, which radiated over the entire abdomen, and she frequently vomited. She died in a state of collapse twenty hours after the onset. At postmortem examination, a large clot and much fluid blood were found in the abdomen. The spleen was shrunken, pale and flabby, the lower pole being "muddy pulp." The other abdominal organs disclosed no abnormality.

In 1878, Skerritt [7] reported a case.

CASE 8.—A man, aged 53, had complained of nausea, anorexia and pyrosis for two months. He had had an attack of severe nosebleed. He was admitted because of a second attack, showing signs of severe hemorrhage. No abnormality was found on abdominal examination. After being in bed for several hours, the patient became dyspneic and died within an hour.

At autopsy a large intraperitoneal hemorrhage was found, with a ruptured spleen, the tear being on the convex surface and 1 inch (2.5 cm.) long. No microscopic examination was made. The spleen and clot weighed 26 ounces (737 Gm.), but the weight of the spleen alone was not given. The substance was described as soft and pulpy, owing to postmortem changes.

5. Rhame, J. S.: Ann. Surg. **88**:212, 1928.
6. Atkinson: Ann. Surg. **2**:403, 1874.
7. Skerritt: Brit. M. J. **1**:641, 1878.

AUTHOR'S CASE

I have one case to add to those already cited.

CASE 9.—The patient was first seen on the operating table after the appendix had been removed, and free old blood had been found in the peritoneal cavity. A lower right rectus incision had been made. I continued this upward and

Fig. 1.—Longitudinal section of spleen, showing hematoma almost bisecting it.

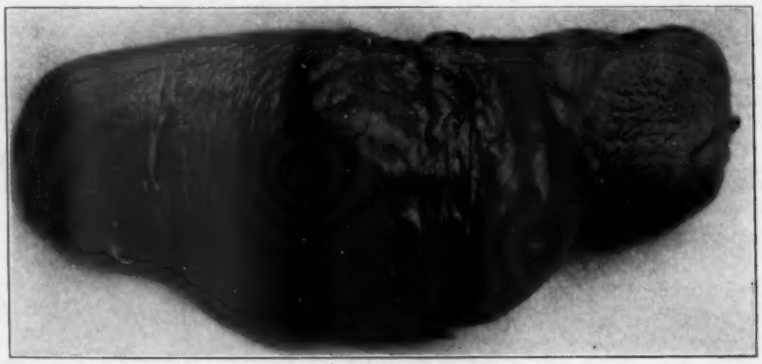

Fig. 2.—Convex surface, showing elevation of capsule with hematoma beneath.

explored the entire right side of the abdomen. The gallbladder was thick, gray and adherent to the hepatic flexure. It was not disturbed. As no cause was found for the bleeding on the right side, I slipped my hand over to the left side and found the spleen to be boggy. The incision was closed, and a high left rectus incision was made. The spleen was delivered, found to be bleeding and excised. Blood was found throughout the entire abdomen.

The history obtained subsequent to the operation was as follows: On Jan. 20, 1929, while sitting in a small chair, the patient developed a severe sticking pain in the left side below the costal margin. This gave him considerable difficulty in breathing. He thought that he was about to have a bowel movement and walked into the toilet. He had no movement, however, and about ten minutes after the onset of the pain he became faint and lay down. One-half hour later he got up and walked to his own home next door. The pain became less, although it was still present. It was more severe when the patient was lying down than when he was sitting up. From that time until January 25, when he was operated on, he still had pain, which was present at all times and increased when he breathed or moved about.

The past history was unimportant from an etiologic standpoint. He "had always been well," had had none of the ordinary diseases of childhood, and, except for an occasional attack of grip or cold lasting for a day or two, he could remember no time when he felt bad. He had not had malaria, typhoid, syphilis or any other chronic disease. He had had no gallbladder or other

Blood Counts Subsequent to Operation

Date	White Blood Cells	Red Blood Cells	Hemoglobin, per Cent	Color Index	Polymorphonuclears	Large Lymphocytes	Small Lymphocytes	Transitionals	Eosinophils	Basophils
1/29/29	19,850	5,552,000	95	0.9	95	4	4	..	..	..
1/30/29	19,200	5,824,000	95	0.8	89	10	..	..	..	1
1/31/29	26,100	5,776,000	95	0.9	87	13	..	..	..	..
2/ 2/29	15,950	6,204,000	100	0.9	90	8	2	..	..	..
2/ 4/29	23,225	5,600,000	95	0.8	91	5	4	..	..	..
2/ 5/29	23,150	4,624,000	100	1.0	84	13	..	..	2	1
2/ 6/29	18,000	4,736,000	100	1.0	81	5	8	..	1	..
2/ 7/29	21,950	4,992,000	95	0.9	82	12	2	..	1	2
2/ 8/29	22,350	5,672,000	95	0.8	84	5	8	3	..	1
2/ 9/29	20,450	5,450,000	100	1.0	82	11	5	1	1	..
2/11/29	14,850	5,360,000	95	0.9	87	6	6	1	..	..
2/12/28	16,680	5,460,000	95	0.9	87	8	..	2	..	3
2/13/29	14,850	5,508,000	95	0.8	83	7	6	1	1	2
2/14/29	11,350	5,088,000	100	1.0	64	21	5	6	1	3
2/15/29	10,100	5,216,000	100	1.0	69	24	5	2	..	..
2/16/29	11,100	5,248,000	100	1.0	65	22	8	..	1	4

abdominal symptoms. His mother died of carcinoma of the stomach, and one brother died of nephritis. He had stopped work four days previous to the onset of pain. He had had no accidents. He was a brickmaker.

On entrance to the hospital, examination disclosed moderate tenderness and rigidity over the entire abdomen, somewhat greater over the left upper quadrant, pain particularly about the umbilicus, a temperature of 100.4 F., and a leukocytosis of 18,200 with 80 per cent neutrophils. Examination of the blood made the day after operation showed: a negative Wassermann reaction, Widal test and blood culture.

A report of the blood counts made for two weeks after operation are given in the accompanying table.

The spleen weighed 156 Gm. and measured 17 by 18 by 2 cm. Over the anterior upper third there was an elevated area 8 by 7 cm. in which the capsule was separated from the spleen and when opened exuded clotted blood. From this there was direct communication into the splenic tissue. A similar small area was noted on the opposite side. The remaining splenic tissue was of normal color and consistency. Section longitudinally showed a normal appearing spleen except for areas of hemorrhage.

Microscopic section showed an increase of the fibrous elements with marked thickening and hyalinization of some of the blood vessels.

The postoperative course was somewhat stormy. On the second day, he became distended and developed an acute dilatation of the stomach. About the tenth day, he had what seemed to be an attack of cholecystitis, and a week later while at home he had a second attack. From that time on he had been in good health.

COMMENT

The symptoms, except for the history of trauma, were not unlike those of traumatic rupture, although on the whole they were less severe. Sudden severe pain in the upper part of the left side of the abdomen was the only symptom common to all cases. Vomiting was present in four cases, shock in four cases, dulness in the flanks in two cases, pain in the left shoulder in two cases and in the right shoulder in one; rigidity was present in three, and tenderness in four cases. Distention was present in two cases. In none of the nine cases was the condition correctly diagnosed previous to operation.

Eight cases occurred in males and one in a female. The two patients with doubtful cases died without operation, and the ruptured spleen was found at autopsy. Six of the seven patients operated on recovered, and one died. Death was due to paralytic ileus. One patient returned for operation three months later for a pancreatic cyst.

Spontaneous rupture of the pathologic spleen is not uncommon. Malaria [8] is the disease in which the spleen ruptures most frequently; typhoid [9] is probably the next. Cases have been reported in hemophilia,[10] pregnancy,[11] tuberculosis,[12] acute infections [13] and a few other conditions.

Susman summed up the views on the causes of spontaneous rupture as follows:

(1) Softening of all the structures of the spleen.

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8. Rankin, W.: Brit. M. J. **2**:211, 1917. Ogilvie, W. B.: Brit. M. J. **1**: 200, 1916. Skevington, J.: Brit M. J. **1**:571, 1920. Sheaf, E. W.: Brit. M. J. **1**:767, 1920. Lutten, in Nothnagel: Special Pathology and Therapy, p. 245. Turner, G. G.: Lancet **1**:799, 1917. Noland and Watson: Ann. Surg. **57**:72, 1913.

9. Connor and Downes: Am. J. M. Sc. **147**:332, 1914. Bryan: Ann. Surg. **1**:856, 1909.

10. Hammesfahr, C.: Zentralbl. f. Chir. **1**:1634, 1923. Friesleben, M.: Deutsche Ztschr. f. Chir. **173**:45, 1922.

11. Stretton, J. L.: Brit. M. J. **50**:901, 1926. Simpson: Edinburgh M. J. **12**:268, 1866. Hubbard: New York M. J. **30**:75, 1879. Schwing: Zentralbl. f. Gynäk. **4**:291, 1880.

12. Cannaday: Tr. South. Surg. & Gynec. Assn. **27**:514, 1914.

13. Fieber, E. L.: Wien. klin. Wchnschr. **34**:581, 1921. Millar: Brit. M. J. **2**:490, 1916. Diehl, H. S.: Spontaneous Rupture of the Spleen Following a Carbuncle, J. A. M. A. **82**:951 (March 22) 1924. Lampe: Deutsche Ztschr. f. Chir. **44**:407, 1897.

(2) Congestion of the portal vein and its radicles and inability of the narrow splenic vein to accommodate itself.

(3) Blood being thus forced between the spleen and the investing peritoneum which finally gives way and

(4) Perisplenic adhesions which, by fixing the organ, predispose to rupture.

That spontaneous rupture of the normal spleen ever occurs is denied,[14] but evidence from the eight ruptured cases and my own would seem to indicate that such a condition has occurred. Two theories may be entertained as causes of such rupture. The first is that the spleen is not normal in its entirety, but that the rupture occurs at a localized diseased area, and that this area is destroyed by the hemorrhage resulting from the rupture. The digestive juices of the stomach are decreased following removal of the spleen,[15] and probably the spleen supplies a substance the loss of which would cause the stomach to secrete less pepsin. From this Susman suggested that the disease of the spleen, as yet unrecognizable or localized, causes the disturbances of the digestive system. In support of this view, he wrote that of the seven cases reported up to the time of his article, "five patients had digestive symptoms, two had conditions in the other organs sufficient to account for these symptoms—namely, gall stones and tuberculosis respectively; in the remaining three no cause for the gastric symptoms was discovered." Of the two subsequent cases, that of Rhame disclosed no concurrence or previous disease, while mine showed evidence of a diseased gallbladder.

The second theory is that the rupture of the normal spleen is not spontaneous but traumatic. Lempriere[16] reported a case in which a small rupture of the spleen occurred; it stopped bleeding but eight days later during exercise rupture occurred for a second time.

Jackson[17] reported the case of a patient operated on twenty-eight days after injury to the left side caused by a desk at school. At the time of the injury, she felt only slightly unwell. Cases of traumatic rupture are reported in which the injury was not commensurate with the pathologic condition. The spleen may also be injured by indirect violence,[18] as that caused when a person twists to escape falling or when there is a sudden and violent contraction of the abdominal muscles.

The spleen is a contractile organ having systole and diastole. It also varies in size, increasing after eating. It has what may be considered a

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14. Ledderhose, in Billroth, and Luecke: Deutsche Chirurgie, Stuttgart, 1890, vol. 45, p. 147. Foucault: Je de méd. de Bordeaux **32**:1002, 1925.

15. Moynihan: Bradshaw Lecture, 1920.

16. Lempriere: Brit. M. J. **1**:581, 1923.

17. Jackson, J. N.: Surg. Gynec. Obst. **41**:362, 1925.

18. Gordon-Watson: Choucés System of Surg., vol. 2, p. 3.

normal variation in size, dependent on the load thrown on it by the necessity of eliminating blood cells and toxic products.

Six of the nine patients gave a possible history of indirect violence. Of these, two had nausea and vomiting, one nausea and retching and one experienced strain from reaching down to lift a bucket of water. The other two had bronchitis. It is not stated that the rupture occurred during coughing or retching, but it is possible that as these complaints had been present for a long time and were of frequent occurrence they were not associated by the patients with the onset of the pain. In the other three cases, there is no history of any form of trauma.

In my case, the spleen ruptured while the patient was sitting quietly in a chair. Two patients had definite disease of the gallbladder without symptoms. One had eaten a heavy meal just before the rupture, and another had had a large drink of cold water; two had had gastric symptoms without demonstrable pathologic change; in one, the history was altogether negative, and in one a beginning thrombus was present.

A diseased spot in the spleen may have caused some of these ruptures, recent trauma others and remote injury still others; but on the basis of the evidence presented, I do not feel that spontaneous rupture of the normal spleen may be considered nonexistent.

MULTIPLE MALIGNANT ADENOMAS OF THE KIDNEY *

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Large adenomas of the kidney are rarely reported in the literature, but small tumors of this type varying in size from 2 mm. to 2 cm. are often found at necropsy. Kretschmer [1] recently reviewed seventeen cases of the former type in the literature and added a case of his own. We are reporting another case, the third in which operation was performed and the third reported from the Mayo Clinic.[2]

REPORT OF A CASE

A man, aged 46, came to the Mayo Clinic complaining of stomach trouble, weakness, constipation and a palpable tumor in the left hypochondrium. His father had died of carcioma of the rectum at the age of 60. The patient had malaria in 1894, and in 1909 he had a "nervous breakdown" and a hemorrhoidectomy was performed. He stated that since he was 20 years of age he had had severe indigestion, characterized by gaseous distention, nausea and epigastric heaviness. Because of constipation he had required cathartics daily for years. During the last six months, the weakness had become progressively worse. Two weeks prior to examination, he consulted his family physician because of the dyspepsia. At that time, a tumor was found in the left side of the abdomen, and a roentgenogram was advised.

The patient appeared to be nervous and frail. His height was 5 feet 5 inches (165 cm.), and his weight, 120 pounds (54 Kg.); he claimed this was his usual weight. The pulse rate was 90; the temperature was 97.8 F. The systolic blood pressure was 118 and the diastolic 78, measured in millimeters of mercury. There was a brown patchy discoloration of the skin in the regions of the axilla, groin and buttocks. Anteriorly, a mass extended from the left costal arch almost to the iliac crest. This extended posteriorly into the costovertebral angle, and moved with respiration. It was firm and painless and irregular in outline. The region of the right kidney was normal on palpation, but had a large varicocele on the left side. The specific gravity of the urine was 1.016; the reaction was acid, and the albumin was graded 1. There was an occasional pus cell in each low-power microscopic field. The blood urea was 22 mg. in 100 cc. The hemoglobin was 81 per cent, the erythrocytes numbered 5,070,000, and the leukocytes numbered 7,100. The Wassermann reaction of the blood was negative. A test meal showed

* Submitted for publication, Aug. 3, 1929.

1. Kretschmer, H. L., and Doehring, C.: Adenoma of the Kidney, Surg. Gynec. Obst. **48**:629, 1929.

2. Foulds, G. S.; Scholl, A. J., and Braasch, W. F.: A Study of Histology and Mortality in Renal Tumors, S. Clin. N. Amer. **4**:407, 1924. Judd, E. S., and Simon, H. E.: Benign Adenoma of the Kidney, Surg. Gynec. Obst. **44**:169, 1927.

the total gastric acidity to be 40 and free hydrochloric acid 16 in a total quantity of 80 cc. Roentgenograms of the chest and stomach were normal; a roentgenogram of the kidneys, ureter and bladder disclosed a large shadow in the region of the left kidney, and a spina bifida of the fifth lumbar veterbra. Examinations showed that the eyes, ears, nose and throat were normal. Three teeth showed evidence of periapical infection.

Cystoscopy revealed a normal bladder and normal ureteral meatuses. Clear spurts of urine appeared from each ureter. Catheters passed to each kidney without difficulty. Specimens of urine, collected from the kidneys through catheters in the ureters, did not contain pus. A few blood cells were present, but were

Fig. 1.—The left pyelogram shows the outline of a large pelvis with the superior and inferior calices unusually broad and somewhat elongated. The middle calix is abbreviated. The outline of the lower calix is irregular in density, suggesting cortical pressure. The kidney is large.

assumed to be traumatic in origin, as a second specimen from the left kidney did not contain blood. Indigocarmine injected intravenously appeared in four minutes from each ureter, with concentration graded 4. A pyelogram was made on the left side (fig. 1) and showed the outline of a large renal pelvis, with the superior and inferior calices unusually broad and somewhat elongated. The middle calix was apparently abbreviated. The lower calix was irregular in density, suggesting cortical pressure. The diagnosis was indeterminate, but a polycystic kidney or a single cyst of the lower pole was considered. A pyelogram was then made on the opposite side, which was negative, thus excluding polycystic disease. A differential intravenous phenolsulphonphthalein test showed a normal return from each

Fig. 2.—The posterior surface of the left kidney shows normal substance in the center with the largest tumor attached to the lower pole. The capsule has been removed from the tumors and the kidney.

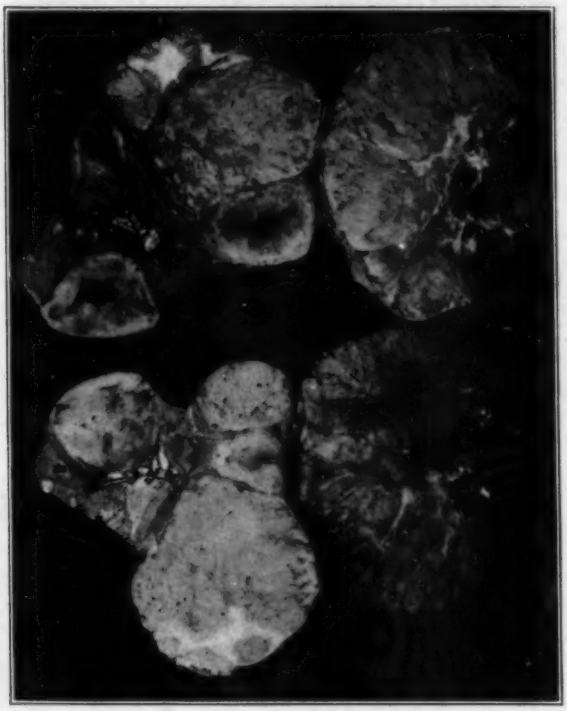

Fig. 3.—A cross-section of the kidney shows multiple adenomas; the largest is 12 cm. in diameter. Normal renal tissue seen on the left is being compressed by multiple adenomas. A small adenoma may be seen in the cortex of renal tissue.

kidney. A urologic diagnosis was made of the tumor of the left kidney, evidently a solitary cyst of the lower pole, with unimpaired renal function. Exploration of the left kidney was advised.

The gastro-intestinal symptoms were explained by the constipation, with possibly a secondary relationship to the renal lesion. Pigmentation of the skin suggested hyposuprarenalemia associated with the renal condition, but because the blood pressure was not low, this was considered unlikely.

At operation a left oblique lumbar incision was made. The kidney was about five times the normal size, nodular in shape, and moderately adherent to the surrounding tissues. At the lower pole was a large rounded tumor, and multiple

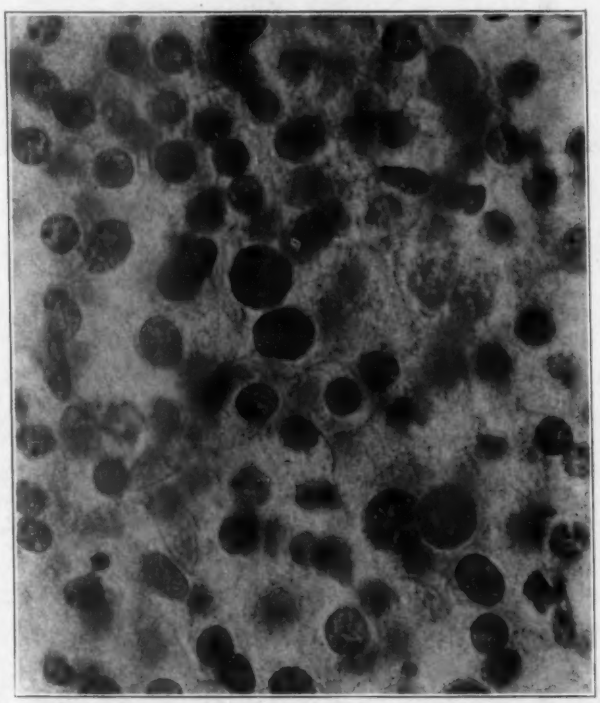

Fig. 4.—In the center and right lower quadrant are definitely malignant cells with large nuclei and multiple large nucleoli; × 250.

firm, smaller nodules surrounded the kidney. As the mass was retracted forward and upward, there appeared to be a small amount of renal tissue remaining on the posterior aspect. The pelvis, ureter and vascular pedicle were in practically their normal positions. The ureter was cut at about 5 cm. distal to the pelvis, ligated and dropped back. The vascular pedicle was cut and doubly ligated.

PATHOLOGIC DATA

The kidney was about five times the normal size (fig. 2). When sectioned through the long axis (fig. 3), the capsule stripped with difficulty. On the cut surface there were five distinct grayish-red tumors, the largest 12 cm. in diameter, all surrounding a small amount of normal-appearing renal tissue. In the cortex

of the kidney just beneath the capsule were two small tumors, 3 and 5 mm. in diameter. There were several trabeculated areas of white shiny material resembling connective tissue which radiated from near the center of two of the tumors. One tumor also had a dark area that appeared to be the result of hemorrhage.

When the capsule was stripped from the mass, the renal substance radiated over the surface of the tumor until it became so thin that it appeared to act as the capsule of the tumor. Each tumor appeared to be encapsulated and definitely benign, but on microscopic examination this was shown not to be the case.

Microscopically, tumorous tissue was seen in juxtaposition to renal tubules and glomeruli (fig. 4). The tumor, however, did not have a capsule; tumorous

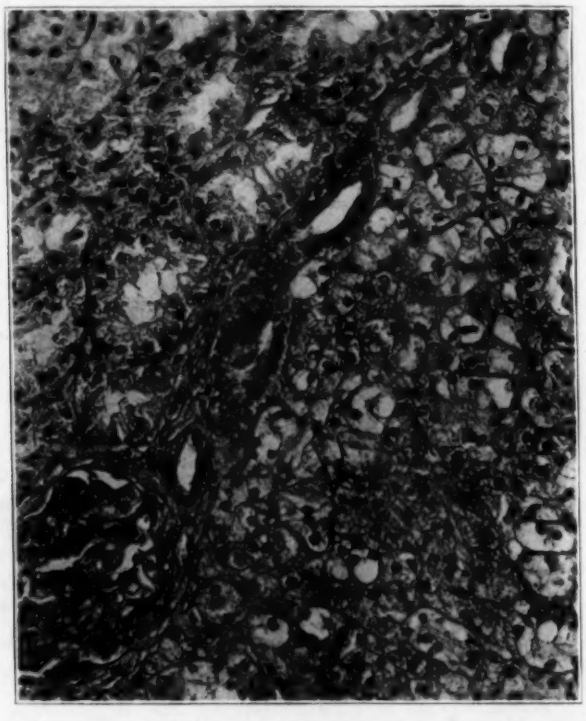

Fig. 5.—Normal renal tissue may be seen in the upper left corner of the section. The tumor is in the lower right part of the field with no intervening capsule. Renal tubules have been compressed in the area between the tumor and the kidney; × 150.

cells adjoined normal renal cells. There was evidence of cortical pressure as the blood vessels and tubules, and the glomeruli were flattened near the tumor. The arrangement of tumorous cells was roughly adenomatous. The cells were polygonal and resembled columnar epithelial cells; they were slightly irregular in shape. A moderate degree of differentiation was present. The cells and their nuclei were larger than normal renal cells. Large nucleoli and deeply staining granules were present, appearing to be definitely malignant cells (fig. 5).

COMMENT

The patient had practically no symptoms referable to the large renal tumor. The adenomas were multiple, varying from 0.5 to 12 cm. in diameter. The kidney was markedly compressed, but the renal function remained normal.

The etiology of adenomas of the kidney is not known. Whether they are malignant or are capable of undergoing malignant degeneration, is important. It was formerly believed that the tumors were all benign. At present, however, certain pathologists believe they are malignant. The degree of malignancy varies, but usually it is relatively low. In the small adenomas found at necropsy, the degree of malignancy is low, but if the patient were to live long enough a large tumor would probably develop. The large tumors usually found in younger persons are more malignant, and closely resemble adenocarcinoma or hypernephroma. In other words, all adenomas of the kidney belong to the so-called hypernephroma type which is important to the surgeon from a therapeutic standpoint. As illustrated in the case presented, small tumors may be present in the renal cortex with large tumors. Should the tumor be resectable in a manner that would leave a functioning kidney, this would seem to be the procedure to carry out. If one keeps in mind the possibility of multiple tumors and of malignancy, nephrectomy would seem to be the best plan if the opposite kidney is normal. It is not possible to determine how long tumors of this type have been present in a given kidney. Growth must be very slow in most cases. Following resection of one pole of a kidney for adenomas, one patient was known to be alive and well eight years later.[1] In another case, two years following nephrectomy for a similar type of neoplasm, the patient is known to be alive and well.[2] There is no evidence in the literature that the tumors metastasize, but the microscopic appearance leads one to believe that they would if the tumor was allowed to grow for a sufficiently long time.

EWING'S SARCOMA

SMALL ROUND CELL SARCOMA OF BONE *

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WITH FOREWORD BY

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FOREWORD

It is important to record here again that Dr. Copeland and Dr. Geschickter were research fellows in the Surgical Pathological Laboratory of the Johns Hopkins University and Hospital for six months only, ending Jan. 1, 1929. Previous to entering on this investigation on tumors of the bone, they had studied the bone material and published in the ARCHIVES OF SURGERY a comprehensive investigation of multiple myeloma. This work was performed while they were medical residents at the Baltimore City Hospital under the supervision of my colleague, Dr. Boggs, and I should like to record here my appreciation of the aid and opportunities that he gave these two young medical graduates. During these six months every tumor of the bone, benign and malignant, and every example of disease of the bone, were studied comparatively, first microscopically and then in the gross and by roentgen and clinical pictures. To make this investigation even more comprehensive, all the benign and malignant connective tissue tumors of soft parts, tendon sheaths, bursae and joints were gone over in the same critical way.

On January 10, two papers by Drs. Geschickter and Copeland were presented before the Johns Hopkins Medical Society and discussed by Dr. James Ewing of New York. The first paper was on "Osteitis Fibrosa and Giant Cell Tumor" and was published in the ARCHIVES OF SURGERY; the second was the present paper on the nature of Ewing's tumor. I have before me a third paper giving the results of their study of the metastasizing and recurrent giant cell tumor. A fourth paper, on osteogenic sarcoma, is almost ready for publication.

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* From the Department of Surgery and the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University.

* Aided by a grant of the Hartley Corporation.

In discussing the two papers before the Johns Hopkins Medical Society, I was asked by one of my colleagues whether I had told the authors all the new things they brought out in their papers. My answer should be published here—No. Dr. Geschickter and Dr. Copeland may be given credit for everything that deserves credit in this series of articles on lesions of the bone, and it is my opinion that they have made valuable and helpful contributions.

The medical profession of this country is "listening in" for any correct information which will help them to interpret properly and treat intelligently lesions of the bone. As the experience of those who see the largest number of patients annually grows, the difficulties of diagnosis increase. This is directly due to the fact that the people are so universally and so well informed that they seek a roentgen study the moment they are aware of any symptom referred to a bone or joint. The clinical picture that was helpful in the past is rarely, alone, helpful today. The roentgenogram in the early stage of the disease in many instances reveals a new picture. In addition, when biopsy is necessary, even trained pathologists are sometimes unable to differentiate between benign and malignant lesions. Roentgenograms are being taken for apparently trivial conditions and after all slight contusions of the bone or sprains of joints so that healed or latent diseases of the bone are being brought into view with which as yet surgeons have little familiarity.

Let me give a few examples from the past year. A postgraduate student was in the roentgen department when a new Coolidge tube was being tested, and offered her leg for a roentgen examination. There had been no symptoms on the part of the fibula. The developed plate showed what was interpreted as a partially healed cyst of the bone in the shaft of the fibula. Up to the present time I have no record of a primary or metastatic malignant tumor being so revealed by purest accident, but about seven years ago, in a roentgenogram of a knee-joint made because of symptoms suggesting tuberculous arthritis, a calcified area was found in the outer condyle of the femur; it was interpreted as healed tuberculosis or ossified bone cyst, and for this reason was not explored. Three years later, I was compelled to amputate this leg for a myxosarcoma, and the patient is now dying of metastasis. It is fair to conclude that if the area had been explored and radically removed, the patient would probably be cured, perhaps without the loss of the limb. On a few occasions, I am inclined to the view that the apparent cure of a lesion of the vertebra diagnosed as a metastasis from cancer of the breast is due to the fact that the disease of the vertebra is caused by tuberculosis or an old fracture. In a patient with Paget's disease of the skeleton and a history of the removal of both breasts for cancer fifteen years previously, there was nothing in the roentgenogram of the skull to suggest the metastasis later found at biopsy.

A recent roentgenogram of the shaft of the tibia in a child, taken because of a lesion that suggested a cyst of the bone, disclosed a malignant aneurysm of the bone lined by osteogenic sarcoma tissue, while another suggesting a malignant tumor proved to be a benign cyst of the bone. A destructive lesion in the ilium diagnosed as primary or metastatic malignant disease proved at biopsy to be granulation tissue. Three months ago, one of my colleagues who is experienced in roentgen diagnosis referred to me a patient with a lesion of the upper shaft of the femur; a positive diagnosis of osteogenic sarcoma had been made, and the patient requested advice as to irradiation or amputation. Subsequent events proved the condition to be osteomyelitis, and the patient was relieved without irradiation or amputation.

Studies of the type of those of Drs. Geschickter and Copeland, based on large series of cases, are therefore welcome. But it must be remembered that the clinical, roentgen and gross pictures are of types of sarcoma of bone observed during the past thirty-nine years. The only uniform observation is a histologic one. Yet, when one compares the sections in these sixty cases of round cell sarcoma arising in the shaft of bones of patients from 4 to 44 years of age with round cell sarcoma of the soft parts, it requires considerable experience to differentiate them. Nor is it always easy, with the microscope only, to pick out with certainty Ewing's sarcoma from multiple myeloma, from some of the cases of chondrosarcoma, from endothelial angiosarcoma and from the granulation tissue of periostitis or osteomyelitis. It is therefore important for pathologists to familiarize themselves with this histologic picture, because as lesions of bone come under observation, it becomes more and more difficult to recognize the nature of the disease from the roentgenogram, with the help of the clinical picture and all other laboratory investigations. Biopsy at the exploratory incision will have to be employed more and more often, until studies of this character in a larger number of more recent cases make it possible to obtain some clue to a more correct diagnosis from the roentgen examination.

In conclusion, it is important to record here again, as I have frequently done before, the safer working rules for the diagnosis of and the treatment for lesions of the bone:

1. If the roentgen and the clinical pictures are obscure and help is wanted in interpretation, do not perform biopsy and send the sections to other departments for examination, but refer the roentgenogram and a report of the clinical picture.

2. While waiting for the diagnosis, keep the part at rest in bed, in crutches or a sling, and give the patient roentgen irradiation. The best results are being obtained with daily treatments for twelve days. Such treatment never does harm. It makes it possible for one to tell whether the lesion is radiosensitive—a valuable point often emphasized by Dr. James Ewing of New York.

3. It is dangerous, more so at the present time, to make a diagnosis of a lesion of the bone from an incomplete study. Roentgenograms should always be made of the uninvolved opposite bone. In addition to this, roentgenograms of the chest and the pelvis should be taken, and I have recently added those of the skull and of the teeth. It should be remembered that many lesions of the bone are multiple—Paget's disease, multiple myeloma, metastatic tumors, osteomyelitis, syphilis, cysts, and, not infrequently, Ewing's sarcoma.

4. Do not be satisfied with one negative Wassermann reaction of the blood. In cases in which syphilis is suspected, give a provocative intravenous treatment, or even a short course of intravenous therapy. In two patients referred to me within the past six months, the limbs were saved by this precaution.

One should remember that Bence-Jones bodies in the urine, except when persistently present, are not always associated with metastatic carcinoma or multiple myeloma. The actual number of cases is recorded by Geschickter and Copeland in their paper on multiple myeloma. Since then I have observed a case of post-typhoid lesion of one rib in which Bence-Jones bodies were found in the urine until after the inflammatory lesion had been explored and drained. In passing, it is interesting to record that the nonsuppurative granulation tissue was difficult to distinguish from myeloma. The recovery of the patient and the presence of staphylococci in coverslips and cultures from the tissue constituted the most positive evidence against multiple myeloma. Fever and leukocytosis with an increase in the percentage of polymorphonuclear leukocytes, as shown by Copeland and Geschickter in this paper, may be observed in sarcoma. However, the definite demonstration of abscesses at the roots of the teeth, infected tonsils or adenoids and a recent history of furuncles, carbuncle or other forms of infection are, for reasons difficult to explain, rarely recorded in the histories of patients with sarcoma, while they are usually present in osteomyelitis.

Do not neglect the clinical history. It is quite possible that as the number of carefully recorded clinical histories of the earliest stages of all types of lesions of bone are increased, valuable differentiating data may again be brought to life.

Do not neglect palpation. Repeat it. It is quite true that the older descriptions of the palpation of benign and malignant lesions of bone no longer hold good, but I am finding new data when palpation is repeated. For example, when palpation was performed on the patient already referred to who had a lesion of the upper third of the shaft of the femur diagnosed roentgenographically as sarcoma, a spindle swelling was found surrounding the femur below the lesser trochanter for a distance of 6 cm. This is the usual manifestation in periosteal sarcoma. There was certain evidence in the roentgenogram that suggested

osteomyelitis. Abscesses at the roots of teeth and infected sinuses were found. After these foci of infection were treated, the encircling spindle-shaped periosteal mass quickly subsided, leaving only on the outer side in the fascia lata a small doughy mass the size of a dollar; as this quickly became detached from the femoral bone, my associates and I were confident from palpation alone that this could not happen in sarcoma. A few days later, this area was explored and a tiny sequestrum was found in a cavity lined by granulation tissue and without pus. Again, the frozen sections of this granulation tissue suggested sarcoma, but organisms in the smears and later cultures practically excluded sarcoma. This sequestrum showed in the roentgenogram. It was not larger than 2 by 3 mm. The finding of this in the first roentgenogram was looked on as evidence against sarcoma.

5. In these cases of sarcoma of the bone in its early stages, there is now evidence of positive cures being effected by resection instead of by amputation, a few by curetting and irradiation and a few by irradiation alone.

In preparation for a demonstration before the Chicago Roentgenological Society, I recently reviewed with a group of special students all our lantern slides on lesions of the bone, and I found that Copeland and Geschickter recorded eight five-year cures in Ewing's tumor, a percentage of almost 13. In 1921, I could record only two five-year cures among fifty-two cases of sarcoma of all types—less than 4 per cent of the total. This great increase of permanent cures is dependent largely on earlier intervention. Every patient cured by irradiation alone, of course, could have been cured by resection or amputation. There is no evidence as yet that irradiation has cured any patient with sarcoma of the bone with metastasis to the lungs.

It is my observation that Ewing's sarcoma of the bone is more radiosensitive than any other type of sarcoma of the bone, and this is why irradiation should be tried first in all doubtful cases.

I can add the following cases to those already recorded by Copeland and Geschickter. First, there is a patient now well seven years after treatment with irradiation alone. The tumor occupied the upper half of the shaft of the humerus. To have removed it would have required a shoulder-girdle amputation. There is no proof, except the suggestive x-ray picture, that it was a Ewing tumor.

Almost three years ago, Dr. Campbell of Memphis explored a lesion of the lower third of the fibula. Roentgenographically, the lesion was typical of periosteal sarcoma with involvement of the shaft, with both formation and destruction of bone. The section obtained at biopsy showed a Ewing round cell sarcoma. This patient is clinically well. The roentgenograms now show a healed lesion.

More than four years ago, Dr. Watkins of Birmingham referred to me the roentgenograms and tissues of a sarcoma of the shaft of the tibia; microscopically, it was a Ewing sarcoma. Nothing was done beyond curetting and irradiation. The clinical and roentgen pictures now record a healed lesion.

When I go over the records of all sarcomas of the bone, there is no doubt that more patients in the group with Ewing's sarcoma were radiosensitive, and that in a few the condition was temporarily checked by this treatment.

It is interesting to record again that in the cases in the records there is not an example of a five-year cure after amputation for a lesion of the upper extremity or above the middle third of the femur, but there are now five examples of patients with different types of sarcomas of the bone situated in the upper extremities who have remained well after resection. At the present time, I myself would prefer resection to irradiation alone, but if the tumor is situated in the upper extremity or above the middle third of the femur and its local growth prohibits resection, irradiation should be the treatment of choice.

The actual results of conservative treatment for sarcoma of the bone cannot be written today. In a few years sufficient material will have been amassed so that one can decide between amputation, resection, curetting, with and without irradiation, and irradiation alone. There is little evidence that any treatment will affect or cure metastasis to the lung.

Ewing's Sarcoma.—Before the publication of the article by my colleague Dr. Ewing, these sarcomas of bone were differentiated from the osteogenic and other types of sarcoma as periosteal round cell sarcoma or alveolar sarcoma. I agree with Dr. Copeland and Dr. Geschickter that they are justified in picking out these 60 cases to be classed as Ewing's tumors from among the 400 examples of sarcoma of bone. I am inclined to feel that future studies will demonstrate that in the earliest stages this tumor cannot always be segregated by the clinical or roentgen picture, but the demonstration of radiosensitiveness will be suggestive of this peculiar round cell sarcoma, and biopsy will also reveal a typical histologic picture. Let me again repeat a warning: The granulation tissue, periosteal or endosteal, in osteomyelitis, whether syphilitic, pyogenic or traumatic, will closely resemble Ewing's sarcoma.

EWING'S SARCOMA

By Drs. Copeland and Geschickter

Since the introduction of the term endothelioma by Golgi [1] in 1869, various authors have valued this term as a pigeon-hole for many odd

1. Golgi, C., cited by Simon, W. V.: Die Knochensarcom, Ergebn. d. Chir. u. Orthop. **16**:341, 1923.

and unusual tumors the origin and histologic relations of which are still but on the horizon of biologic investigation.

From time to time various tumors have been described as endothelial in origin. Billroth [2] in 1856 described a tumor in this category which he called cylindroma, and Waldeyer [3] later linked the term angiosarcoma with tumors classed as endothelial. Kolazcek [4] in 1878, and again in 1880, in an extensive study, drew a comprehensive picture of such tumors under the term angiosarcoma. The present tendency, however, is to limit the term angiosarcoma to angiomatous tumors in which the unit is the blood vessel and not the endothelial cell. The term perithelioma has also been used to designate the origin of many malignant tumors, as certain types of angiosarcoma, the term being given special prominence by Hildebrand [5] in regard to certain tumors of bone.

Against such classifications, in which comparatively few recognized groups are supported by satisfactory data, among the older authors Ribbert [6] may be considered outstanding. He expressed the view [7] that the endothelial origin of certain tumors of the bone has yet to be proved, and, further, that the mere continuity of the tumor cells with endothelial structures at the margin of the tumor is no proof of their identity. The proof of such an identity rests on the study of the tumor at its inception or at its original formative site. In recent years, Ewing [8] adopted the conception of Borst that the scope of endothelioma is probably wide, allowing him to give full expression to the views of many who favor the endothelial origin of a wide variety of tumors the exact nature of which has not been determined. With this idea in mind, Ewing selected from among the malignant tumors of the bone a nonosteogenic tumor with many clearcut clinical features, placing it within the realm of endothelial tumors, known as endothelial myeloma [9] or diffuse endothelioma [10]

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2. Billroth: Untersuchungen über die Entwicklung der Blutgefässe, Berlin, 1856.

3. Waldeyer: Die Entwicklung der Carcinome, Virchows Arch. f. path. Anat. **55**:67, 1872.

4. Kolazcek, J.: Ueber das Angiosarkom, Deutsche Ztschr. f. Chir. **9**:165, 1878.

5. Hildebrand: Ueber das tubuläre Angiosarkom oder Endotheliom des Knochens, Deutsche Ztschr. f. Chir. **31**:263, 1891.

6. Ribbert, H., cited by Ewing, J.: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928, p. 333.

7. Ribbert, H., cited by MacCallum, W. G.: A Textbook of Pathology, Philadelphia, W. B. Saunders Company, 1928, p. 930.

8. Ewing, J.: Endothelial Myeloma of Bone, Proc. New York Path. Soc. **24**:93, 1924.

9. Ewing, J.: A Review and Classification of Bone Sarcoma, Arch. Surg. **4**:485 (May) 1922.

10. Ewing, J.: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928, p. 351.

of the bone. Connor,[11] in a recent study of the bone material with the Codman Registry, supported Ewing in this view, and Kolodny,[12] in a similar treatise, agreed with Ewing that the tumor presents a clearcut entity, but he did not feel that the contention that it arises from perivascular endothelium was well grounded. McCallum,[13] in a more emphatic way, placed the burden of proof on the investigator who designates any tumor as endothelial in origin, yet felt that in certain instances descriptions of true endotheliomas had been recorded, and he cited such instances in his textbook of pathology.

At the suggestion of Dr. J. C. Bloodgood, the entire collection of tumors of the bone, both benign and malignant, in the Surgical Pathological Laboratory of the Johns Hopkins Hospital (representing, in all, a total of over 1,500 cases together with 1,000 cases of diseases of bone), was made the subject of a comparative histologic study. Later the observations thus obtained were correlated with the clinical data, the gross material and the x-ray pictures. For purposes of microscopic analysis, the tumors were studied and classified according to their cellular elements, stroma and special areas, the special areas connoting old bone, healing bone, hemorrhage, pigment, necrosis, etc. Symbols were given these different elements for the sake of brevity and from the standpoint of standardization in classifying tumors. From among the cases of malignant tumors of the bone, a series of sixty, which were grouped under the name of periosteal round cell sarcoma or Ewing's endothelial myeloma, were selected for the present analysis. The study includes thirteen full case reports on patients admitted to the surgical service of the Johns Hopkins Hospital.

ETIOLOGIC FACTORS

Ewing's sarcoma [14] is essentially a disease of early life; 95 per cent of the cases in this series occurred in persons between the ages of 4½ and 25. In this respect, it does not differ from other sarcomas of bone, the majority of the cases of which occur in the first two decades of life. The youngest person whose case was reported in our series was a child aged 4½, while the oldest was a white woman aged 44, although Connor reported a case in a patient aged 60 (fig. 1).

Among the 400 sarcomas of the bone in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, 15 per cent were found

11. Connor, C. L.: Endothelial Myeloma, Ewing, Arch. Surg. **12**:789 (April) 1926.

12. Kolodny, A.: Bone Sarcoma, Surg. Gynec. Obst. **44**:126, 1927.

13. MacCallum, W. G.: A Textbook of Pathology, Philadelphia, W. B. Saunders Company, 1916, p. 928.

14. Codman, E. A.: The Nomenclature Used by the Registry of Bone Sarcoma, Am. J. Roentgenol. **13**:105, 1925.

to be Ewing's sarcoma. Males affected predominated over females in an approximate ratio of two to one (thirty-nine males and twenty-one females). With relation to color, the tumor was apparently rare in all races save the Caucasian; only one case in the series occurred in a negro.

Trauma was recorded in twenty-two cases, although the actual number in which it occurred was probably greater, since in many instances trauma was not sought for or was not recorded. In every case in which trauma was recorded, the trauma was definitely related to the subsequent onset of the clinical symptoms. The average lapse of time between the trauma and the onset of clinical symptoms was approxi-

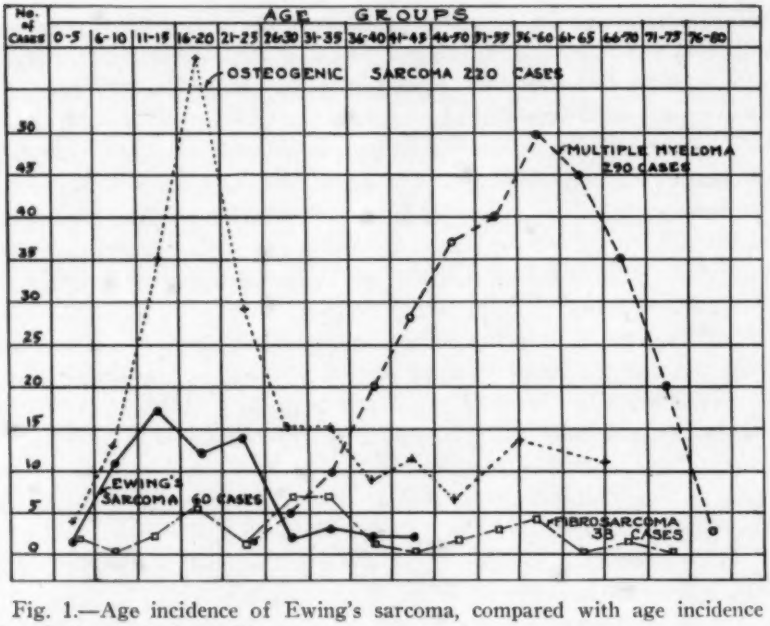

Fig. 1.—Age incidence of Ewing's sarcoma, compared with age incidence of other malignant lesions of bone.

mately five and one half months, the extremes being a few days and a year or more.

In considering trauma as an etiologic factor, the question always arises whether the injury was superimposed on an already existent tumor or whether it actually was the stimulus to production of the malignant growth. There are some grounds for assuming either conclusion, but in our series the majority of such injuries reported undoubtedly preceded the disease.

CLINICAL CHARACTERISTICS

Pain.—Pain was an outstanding symptom in fifty cases (83 per cent), and was noted as the first symptom in twenty-one cases (35 per

cent). In most cases, pain began spontaneously; it followed trauma at times by a more or less short period, often appearing simultaneously with the formation of the tumor.

In twenty cases, pain had been present for from five weeks to seven months before the patient came under observation, and in nine cases it had been present for from one to two and one half years prior to clinical observation.

A wide variation in the severity of the initial pain was apparent; in some cases it was cramplike, while in others it was either a sharp shooting pain or an aching only on motion. Most frequently, the pain was intermittent, lasting for from a few hours to several days, subsiding at intervals, only to recur with increasing severity. The intervals between the attacks of pain became shorter in duration until a constancy of discomfort was noted by the patient, the pain at certain times being accentuated. Nocturnal pain was the most severe, in many cases. A pain concomitant with the appearance of tumor was not an unusual observation, remaining constant until spontaneous regression of the tumor occurred or until some operative intervention was resorted to.

The characteristic course of the pain may be summed up as follows:

Stage 1: Tenderness or soreness following trauma or arising spontaneously on motion.

Stage 2: Intermittent pain of a dull, aching or sharp shooting character, lasting from a few hours to several days.

Stage 3: Periods of freedom from pain.

Stage 4: Continuous pain either of a dull aching or sharp shooting nature appearing with progression in the size of the tumor or spontaneously, and subsiding after regression in the size of the tumor or after operative or x-ray treatment.

In almost every case in which sufficient data were available, two or more of these stages were noted.

Tumor.—In 56 cases (90 per cent), a mass could be palpated, and in 19 per cent of the cases a swelling was complained of as the initial symptom. The average duration of the formation of the tumor, as observed clinically or by the patient himself, was thirteen and one-half months, the periods ranging from three months to two years. One exception to the period of tumor formation mentioned is of interest, namely, a case under observation in which there was a history of tumor extending over a period of seven years, the tumor showing many regressions and recurrences prior to the patient's admission to the hospital.

In only two cases was tumor the only manifestation of the disease. In the majority of the cases trauma, pain and tumor or pain and tumor were the syndrome. In many cases, the tumor was preceded by pain or trauma for a period ranging from two months to one year.

The tumor masses varied from small localized swellings to large fusiform masses extending along almost the entire length of the affected bone. There were vasomotor changes about the growth, in many cases. The soft parts about the tumor in most cases were freely movable, but often were edematous, while in other cases there was only dilatation of the peripheral veins over the tumor without any disturbance of the fluid exchange in the tissues. In many instances there was a local elevation of the temperature over the tumor mass.

On palpation, the majority of the tumors presented an indurated swelling with a surface ranging from rough and irregular to smooth, and totally immobile, apparently continuous with the bone. Fluctuation of the tumors was not noted, though there were varying degrees of resilience, all being less hard than bone. Many of the tumors were tender on palpation.

TABLE 1.—*Bone Involvement*

Bone Involved	Total Number of Cases	Cases in Upper Shaft	Cases in Lower Shaft	Cases in Mid-Shaft
Tibia	15	6	3	6
Femur	13	5	7	1
Humerus	7	4	1	2
Fibula	8	3	2	3
Radius	1	..	1	..
Ribs	1	..	..	1
Pelvis *	5	..	..	..
Scapula	4	..	..	..
Clavicle	2	..	..	..
Metatarsal	2	..	..	..
Tarsal	1	..	..	..
Skull	1	..	..	..

* Ilium, four cases, and one case undetermined.

A peculiar feature in some of the tumors was their tendency to spontaneously decrease in size, with a sudden cessation of pain, and thus to disappear and reappear until some remedial treatment was instituted. Perhaps the variability in the size of the tumor at various times had to do with hemorrhage and the absorption of hemorrhage.

The bones most frequently involved were those of the long pipe bone class (table 1), although in a few instances the ilium, scapula, clavicle, skull and bones of the feet were affected (fig. 2). In no case was the primary location of the tumor on other than the shaft side of the bone, where the long bones were involved. No predilection of the tumor for the right side or the left side of the body was noted; twenty-two cases occurred on the left side and twenty-three on the right side of the body. Those bones that are most readily subjected to trauma were the ones most frequently affected; i.e., the femur, tibia, humerus, fibula and pelvis, the tibia leading the list with an involvement in fifteen cases of this series.

Fracture.—Pathologic fracture is of relatively rare occurrence in Ewing's sarcoma. It was noted in only three cases of this series, or 5 per cent. These fractures were of the femur, two occurring in the upper shaft and one in the lower shaft. Of all the malignant tumors of the bone, Ewing's sarcoma presents the minimal number of cases complicated by pathologic fracture. As was pointed out by the authors [15] recently, multiple myeloma heads the list of malignant tumors of bone, in this respect, with pathologic fractures in 62 per cent. Other

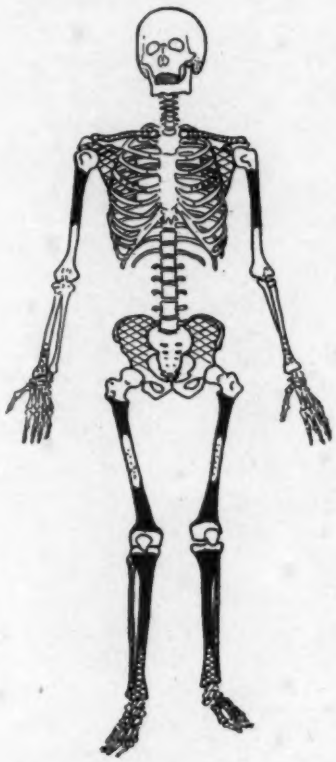

Fig. 2.—Incidence of Ewing's sarcoma according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal lines, the occasional sites and the dotted areas, rare sites. The areas in white were not involved by tumor in this series.

bone tumors similarly affected by fracture are, in the order of frequency: bone cysts, 45 per cent; giant cell tumor, 14 per cent; and general sarcoma of bone, 8 per cent. The low frequency of

15. Geschickter, C. F., and Copeland, M. M.: Multiple Myeloma, Arch. Surg. **16**:807 (April) 1928; Osteitis Fibrosa and Giant Cell Tumor, ibid. **19**:181 and 201 (Aug.) 1929.

pathologic fracture in round cell sarcoma is against the current opinion that this tumor is a primarily bone-destructive neoplasm, although pain of the affected part (due to weight bearing) may, in some instances, have saved the limb from this complication.

Constitutional Reaction.—The consideration of fever was handicapped by the sparsity of information in many of the case histories; only those are included here in which the temperature was recorded; in all, 28 reports. The range of the elevation of temperature was between 99 and 104 F., the average being 100. These elevations of temperature were more commonly observed late in the disease, after metastases had occurred; but fever was noted early in the clinical course in 30 per cent of the cases. Associated with this fever, in many cases, was a slight albuminuria and the presence of a few white and red blood cells in the urine. Though a search for Bence-Jones bodies was apparently not a routine procedure, in the cases in which the test for these bodies was carried out, they were not found in a single instance.

In cases in which the blood was examined in detail, the picture ranged from that of the normal type to that of a secondary anemia and from that of relative leukopenia to that of marked leukocytosis. Of thirty-one cases in which complete blood counts were made, five presented red cell counts of 5,000,000 or more and an equal number, red cell counts of 4,000,000 or more. The remaining twenty-one cases showed red cell counts ranging between 2,900,000 and 3,900,000. No case showed anemia of the primary type with high color index or severe secondary anemia. The hemoglobin in these cases ranged between 40 and 90 per cent; in thirteen it was from 80 to 90 per cent, and in eighteen it was from 40 to 79 per cent.

The white cell counts presented no peculiarity. Of thirty-one cases in which the white cell count was recorded, eight had counts within normal limits; twenty had counts of more than 10,000 and three of more than 20,000, the average being 15,200. There were no unusual features in the differential counts, save for an occasional eosinophilia ranging from 4 to 20 per cent in a count of 100 cells. The polymorphonuclear cells rarely showed an increase beyond 70 per cent of the total count, though, in one case, they presented an absolute increase in number to 95 per cent. Myelocytes were not noted nor any increase in the number of the mononuclear elements. Leukocytosis was not restricted to cases with metastases, but was often an initial observation early in the course of the disease.

Of peculiar interest is the great variability in the nutrition of the patients suffering from Ewing's sarcoma. In some cases in the series a noticeable loss of weight over a relatively short period of time was observed early in the course of the disease, while in other cases little

or no evidence of undernutrition was seen until the end of the clinical course. The terminal phases of the disease, however, revealed a progressive emaciation in most of the cases observed.

Internal metastases usually presented themselves clinically late in the disease. In many cases, there was pulmonary involvement with pains in the chest, hemoptysis and other clinical manifestations of pulmonary disease. In no case were there primary changes of the lungs due to changes in body stance, as often occurs in multiple myeloma, because in the cases of Ewing's sarcoma the progress of the disease was usually

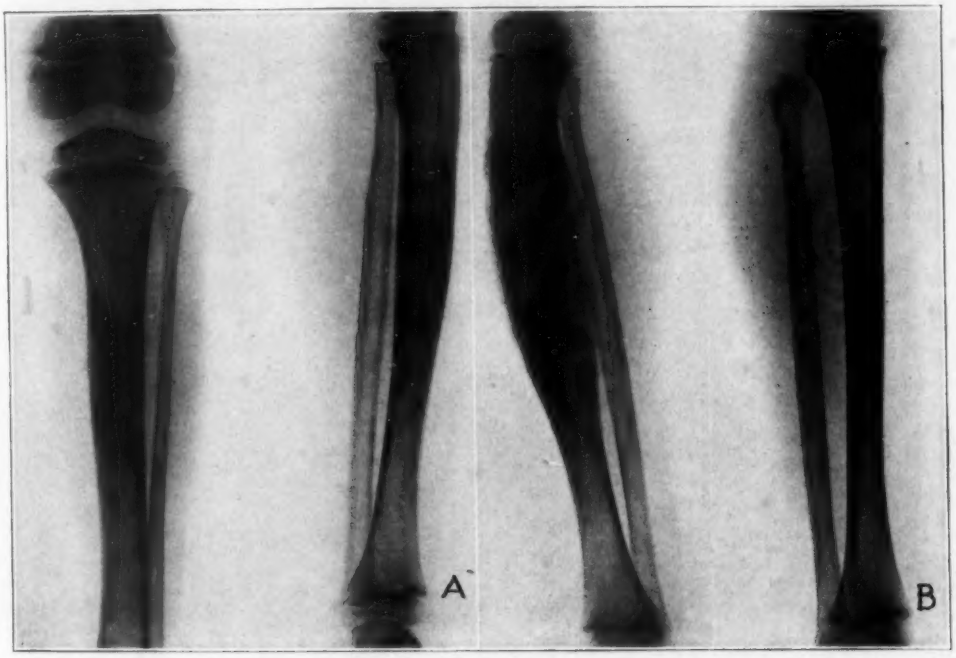

Fig. 3.—*A* is a roentgenogram of a tibia made six months after the onset of symptoms. It shows a slight shadow in the midshaft region of the bone and a slight widening of the cortex, with little if any periosteal reaction. *B* was made eleven days later. It shows increased density of the tumor shadow and a definite periosteal reaction. The normal tibia is included in *B* for contrast.

too rapid, and vertebral metastases, when they occurred, were terminal. In one patient showing choked disks and retinitis, blindness developed, but this was due to metastatic involvement of the cranial vault with protrusion into the cranial cavity rather than to direct involvement of the brain substance. Not infrequently with metastatic involvement of the skull and vertebrae, evidence of motor irritation either of the spinal cord or of the cerebral cortex was expressed in the form of spastic extremities.

Local changes about the tumor were not uncommon, such as dilatation of the veins, hyperemia of the affected part or edema immediately surrounding the area of tumor. Sometimes the entire limb below the site of the lesion was swollen.

ROENTGEN-RAY STUDIES

Ewing's sarcoma, as seen by the x-ray, is most often diffuse and situated near the midshaft region of a long bone. The earlier stages of the lesion present the more difficult diagnosis, and the difficulty is enhanced by the variability in the appearance of the bones affected and infiltrated by the tumor. In one case of this series (fig. 3 *A*) an x-ray picture

Fig. 4.—Ewing's sarcoma in an early stage. There is relatively little medullary involvement, a slight expansion of the shaft and thickening of the cortex. There is a periosteal reaction, looking somewhat like onion peel.

was made six months after the onset of symptoms. When studied, it revealed a slight shadow in the midshaft region of the bone and a widened but apparently well preserved cortex, with little or no periosteal reaction. An x-ray picture (fig. 3 *B*) made eleven days later revealed a fully developed Ewing's sarcoma, with increased density of the tumor shadow and definite periosteal reaction.

X-ray pictures were available for study by the authors in twenty-six cases in this series. Of this number, six represented early stages which showed relatively little medullary involvement, the duration of symptoms having been from two to seven months (fig. 4). The roentgenograms in

these six cases showed a slight expansion of the shaft with a periosteal reaction looking somewhat like onion peel. The cortex of the shaft appeared thickened with some mottling in the region of the medullary cavity, due to areas of increased density. The roentgenograms in the other twenty cases, made later in the course of the disease, showed a considerable part of the shaft affected; apparently, the tumor extended more readily in a plane parallel to the axis of the bone. In the areas thus affected, the medullary cavity often showed osteoporosis and the cortex of the bone evidence of destruction (fig. 5). In all of the cases in this group, there were varying degrees of periosteal reaction besides invasion

Figure 5

Figure 6

Fig. 5.—Ewing's sarcoma involving the shaft of a femur (no. 27511, tables 2 and 5). One may observe the metaphyseal location of the tumor and the predominant destruction of bone. Such destruction, as an outstanding feature, was found late in the disease in the majority of the cases.

Fig. 6.—A roentgenogram of Ewing's sarcoma showing osteophytes at right angles to the cortex, together with a thickening of the cortical bone. This reaction is metaphyseal and diaphyseal (no. 22795, table 5).

of the marrow cavity, but the increased density of the bone in the region of the widened cortex was the most characteristic evidence of infiltration by the tumor.

Osteophytes, arranged irregularly or at right angles to the cortex (fig. 6), appeared in the pictures occasionally. An investigation into

the nature of these osteophytes is of interest and will be presented later in some detail. Suffice it here to say that the perpendicular spicules of bone in Ewing's sarcoma are a normal type of bone formation brought about by a disturbance in the relation of the periosteum to the cortex.

In only two cases did the roentgenogram reveal a suggestive involvement of the epiphysis (fig. 7), and in these cases the epiphyses were subsequently proved to be only secondarily invaded, the original tumor having arisen in the shaft of the bone. When the tumor had invaded the muscles, the soft part shadow was often well circumscribed.

Fig. 7.—Involvement of the epiphysis by Ewing's sarcoma. This was subsequently noted to be a secondary invasion, the original tumor having arisen in the shaft of the bone. Osteophytes may be seen arranged perpendicularly to the cortex, with considerable destruction of cortical bone.

The roentgen-ray observations may be summarized by saying that Ewing's sarcoma expands the shaft of long bones by a diffuse infiltration, which results in a widening and increased density of the cortex and a mottling of the marrow cavity. Both formation of new bone and destruction of bone are secondary to infiltration of bone by tumor. In the early stage, formation of bone predominates, giving rise eventually to either parallel or radiating spicules of new reactive bone. In the later stages, destruction of bone, both medullary and cortical, characterizes the x-ray picture.

The x-ray studies do not support the view that Ewing's tumor is primarily a neoplasm destructive of bone, for in six of seven early cases the first evidence of infiltration by the tumor was an increase in the density of the bone. The typical contour of the involved area in the bone is also against the current conception of the medullary origin of

Fig. 8.—A gross specimen in longitudinal section showing the primary involvement of the shaft with a secondary invasion of the epiphysis. The bulk of the tumor is beneath the periosteum and outside the cortical region. The tumor appears to be well encapsulated (no. 26916, tables 2 and 4).

this neoplasm. Medullary tumors should show an approximately spherical shape in the x-ray picture, because their expansion is unhindered in three and usually four directions. In contrast to this the area infiltrated

by the Ewing tumor is generally elliptical, with its long axis parallel to the shaft of the bone, indicating that the growth is resisted in the two opposite directions.

GROSS OBSERVATIONS

An analysis of the pathologic changes in Ewing's tumor made from gross specimens of bones containing the tumor aided materially in the interpretation of the x-ray pictures. The location was usually the shaft

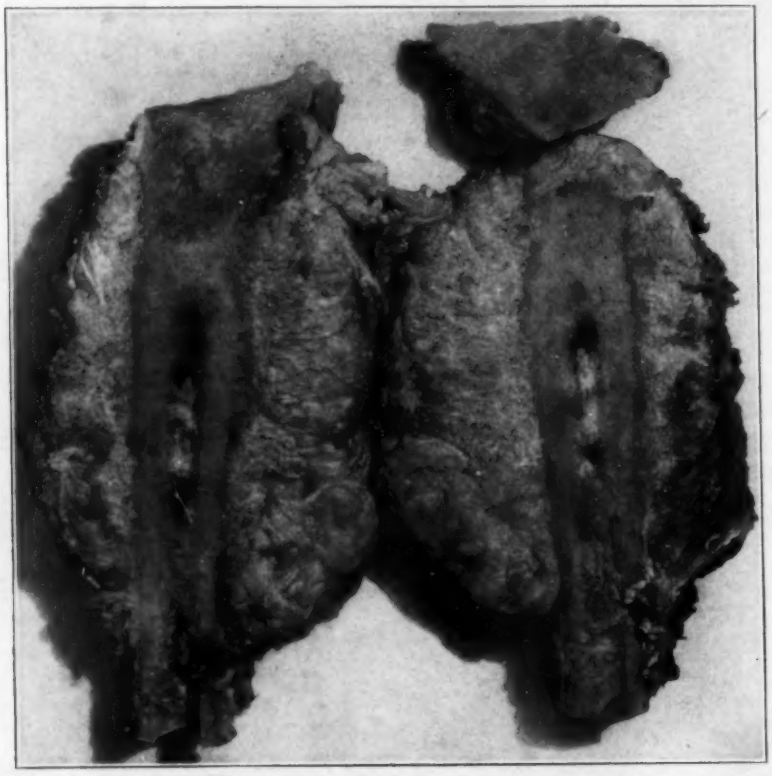

Fig. 9.—A gross specimen of a humerus in longitudinal section. The widened cortex described in the x-ray picture is shown, in the gross specimen, to be made up of subperiosteal and endosteal formation of new bone, which encroaches on the medullary space (no. 37472, table 4).

of a long bone, and the zone of involvement extended from the midshaft region to the epiphysis, the epiphysis being secondarily involved (fig. 8) in but three instances. Regardless of the site of origin of the tumor, all the gross specimens with one exception showed the bulk of the tumor lying subperiosteally (fig. 8). The medullary cavity sometimes contained a small portion of the tumor, but usually this region was constricted or totally occluded by new reactive bone (fig. 9). The widened

cortex described in the x-ray pictures was shown in the gross specimens to be made up of subperiosteal and endosteal formation of new bone, which encroached on the medullary space and frequently sealed it off from invasion by the tumor.

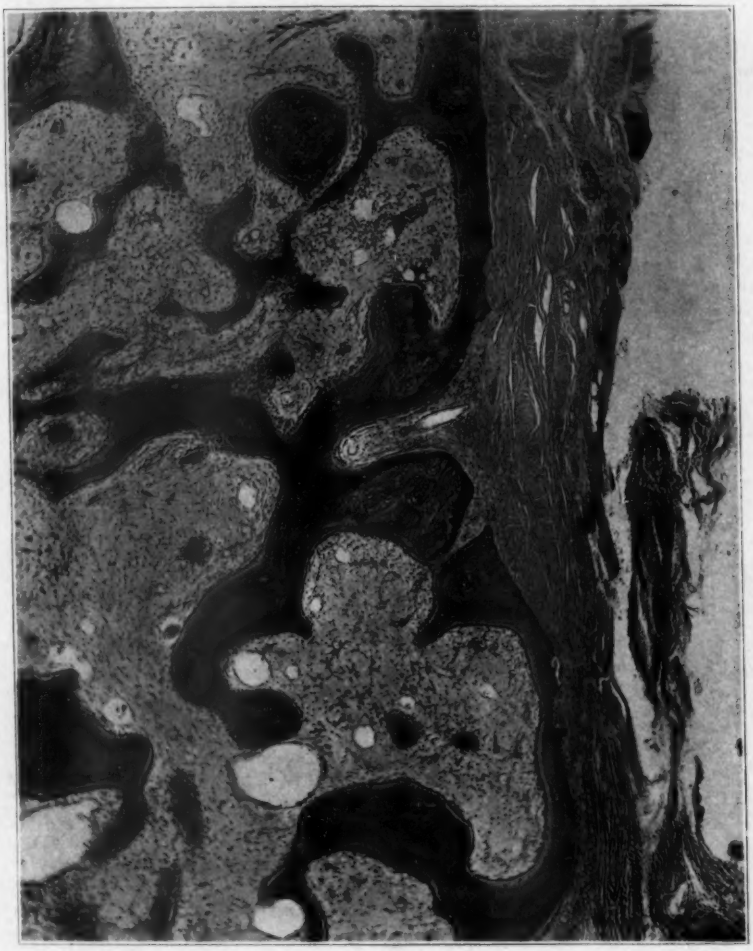

Fig. 10.—A photomicrograph showing the periosteum with its subperiosteal layer forming spicules of reactive bone, peripheral to the invasion by tumor. One may note osteoblasts about the spicules of bone. These spicules constitute the right angle formations of bone seen in the x-ray pictures (no. 34005, table 5).

Although in one case the shaft of the bone surrounded by tumor was almost destroyed, in the majority of the specimens destruction of bone was not a prominent feature. The tumor in its early stages appeared to infiltrate rather than to destroy bone; and the bone thus infiltrated

reacted vigorously with formation of new bone. But the bone subsequently did undergo destruction when surrounded and infiltrated by the tumor, apparently as the result of interruption of the blood supply where the tumor had invaded and blocked the Volkmann and haversian canals.

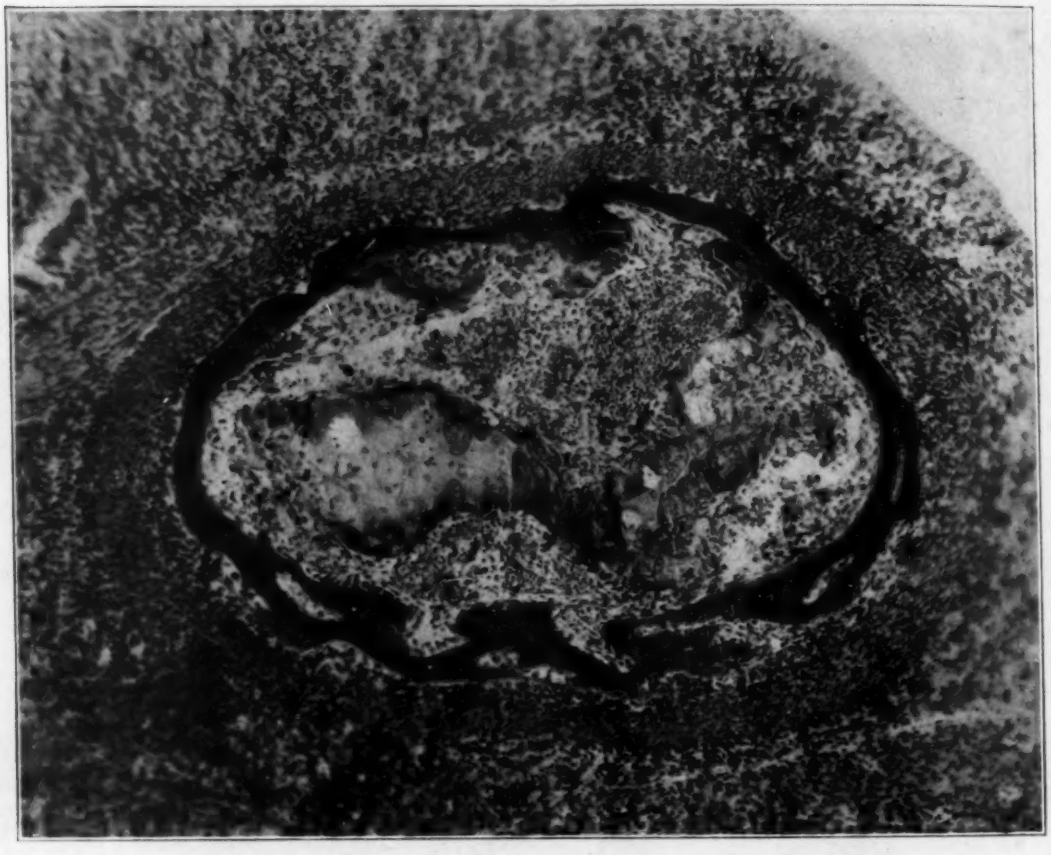

Fig. 11.—A photomicrograph of a cross-section, from the humerus of a human embryo 90 mm. long. One may note the enclosure of vessels by osteoid tissue in the cortical region. The vessels remain as units in the future haversian systems. The cartilage in the center of the bone is being gradually destroyed and replaced by marrow elements.

When the involvement of the bone was diffuse, the subperiosteal formation of new bone was both parallel and at right angles to the cortex (fig. 3). As was pointed out by Buerger [16] in a case of "disso-

16. Buerger, L.: Bone Sarcoma, Surg. Gynec. Obst. **9**:441, 1909; Further Studies of Sarcoma of Bone, Am. J. M. Sc. **140**:355, 1910.

lutive" sarcoma, this normal formation of new bone was fairly striking in various parts of the tumor. The origin of this bone is explained by the mode of advance of the tumor. Due to the growth of the tumor and subsequent hemorrhage, there is a gradual separation of the periosteum from the underlying cortex. The parallel deposits of new bone appear to be the result of proliferation of the peripheral layer of the

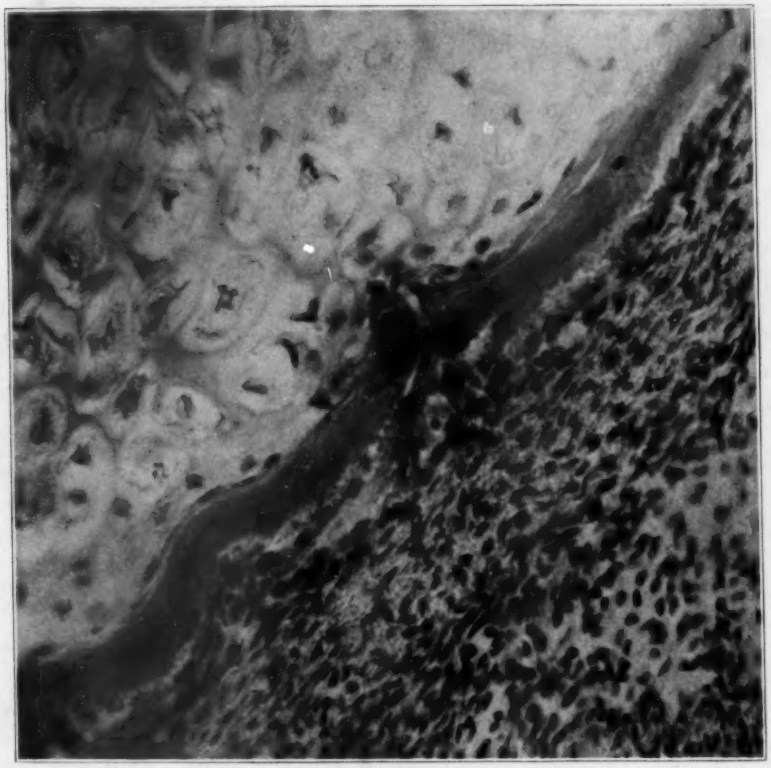

Fig. 12.—High magnification of a cross-section of the humerus from a human fetus 2 months old. It shows the invasion of the osteoid rim and endochondrium by a vessel bud from the fetal periosteum preceded by a giant cell. Volkmann's canals are formed about these periosteal vessels and blended with the haversian systems at a later stage.

cortex when the periosteum has suffered minute separation from the bone. This gives the onion peel-like formation characteristic in x-ray pictures of the early stages. With increased separation of the periosteum, spicules of new bone from the subperiosteal region are laid down at right angles to the shaft rather than parallel (fig. 10). We agree with Ribbert that this is due to the blood vessels perforating Volkmann's

canals,[17] which determine the direction of the new growth of bone when they are pulled outward in maintaining their continuity after the periosteum has been elevated. The two types of formation of bone, parallel and radiating, duplicate the process observed in the embryo. The bone laid down parallel to the shaft is the first to appear in the tumor and also in the embryo. In the first two months of life, osteoblasts about budding vessels lay down osteoid tissue parallel to these channels, and form

Fig. 13.—A longitudinal section of a fibula showing involvement by the tumor. Cysts may be seen at the periphery of the tumor, filled with a dark, pigmented, jelly-like material. The bulk of the tumor is subperiosteal in location (no. 34422, tables 2 and 5).

the inner part of the future cortex, the vessels remaining as units in the future haversian system (fig. 11).

About the second month of embryonic life, this thin osteoid rim of bone is perforated by vessels from the fetal periosteum [15] preceded by giant cells (fig. 12). The reformation of bone about these periosteal

17. Stöhr, P.: Textbook of Histology, Philadelphia, P. Blakiston's Son & Company, 1903, p. 151.

vessels forms the Volkmann's canals seen in the mature bone, which unite the periosteal blood supply with the haversian vessels. This determination of the pattern of the bone by vessel units typical of the embryo [18] is not lost in adulthood.

The soft part tumor formation was usually encapsulated by a thin layer of fibrous tissue, which at its margin was continuous with the

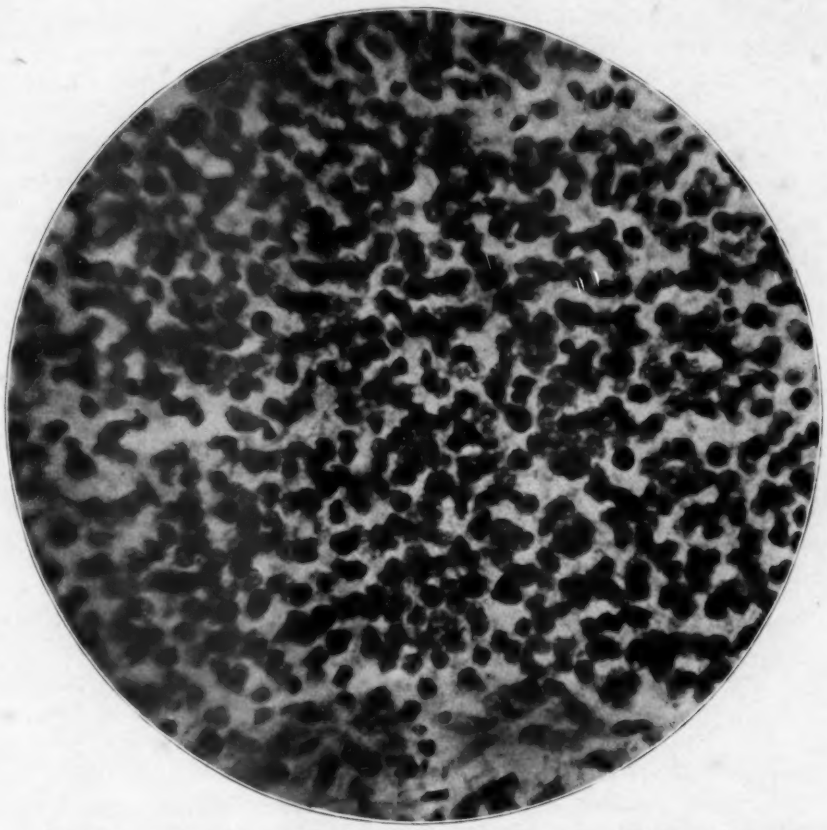

Fig. 14.—A photomicrograph showing the characteristic cell of Ewing's sarcoma. One may note the indistinct cytoplasm and the round and oval nuclei (no. 27039, table 4).

periosteum. The tumor tissue itself, enclosed by this capsule, was firm and grayish-white and was divided into characteristic lobules by a number of connective tissue strands extending from the outer capsule to the region of the cortical bone. Occasionally, the tumor substance showed cysts (fig. 13) at the periphery of the tumor, filled with a dark,

18. Eising, E. H.: Bone Formation in Osteogenic Sarcoma, Arch. Surg. **12:** 867 (April) 1926.

pigmented, jelly-like material. These cysts were due to hemorrhage or regressive changes, for many of the specimens showed soft necrotic areas honeycombing their structure.

MICROSCOPIC OBSERVATIONS

The data at hand indicate that the microscopic characteristics of Ewing's tumor are among the most uniform characteristics of the dis-

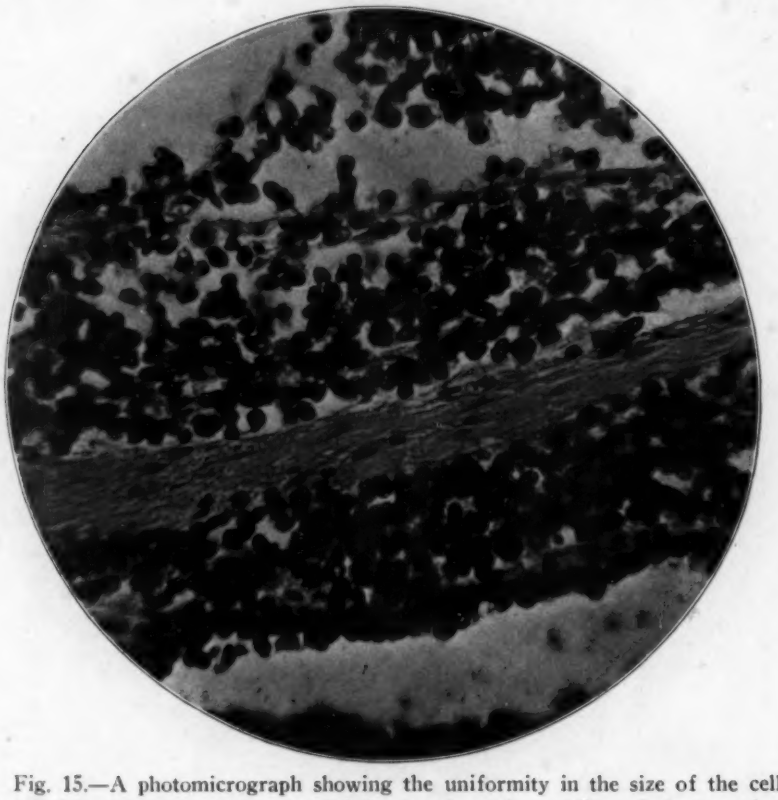

Fig. 15.—A photomicrograph showing the uniformity in the size of the cells. In the less compact region, the definite but irregular outline of the cytoplasm may be noted (no. 24667, tables 2 and 4); a septum is seen traversing the tumor substance.

ease, and thus are a most important aid to the clinician or the surgeon in making the diagnosis. Examination of sections from these tumors without consideration of special areas, which will be considered later, revealed a more or less constant cellular picture. The type of cell in the compact areas was small and polyhedral with a round or oval nucleus (fig. 14). The cytoplasm was scanty and practically stainless.

In less compact regions, the cells showed a cytoplasm with a more definite outline, which surrounded the nucleus with a pale eosin-staining

substance, the periphery of which was irregular (fig. 15). The cells were at times so closely packed that the shape of the individual cell was altered. The nucleus was deeply stained, showing a definite limiting membrane and a sparse scattering of chromatin granules without any definite arrangement. Nucleoli were rarely seen, but mitotic figures were noted not infrequently. The diameters of the nuclei ranged from 7 to 9 microns. Little pleomorphism was observed, and multinucleated cells of tumor origin were not noted. Not infrequently, however, osteoclasts were located in the region of dead bone or a slight distance from the bony tissue in the midst of tumor cells.

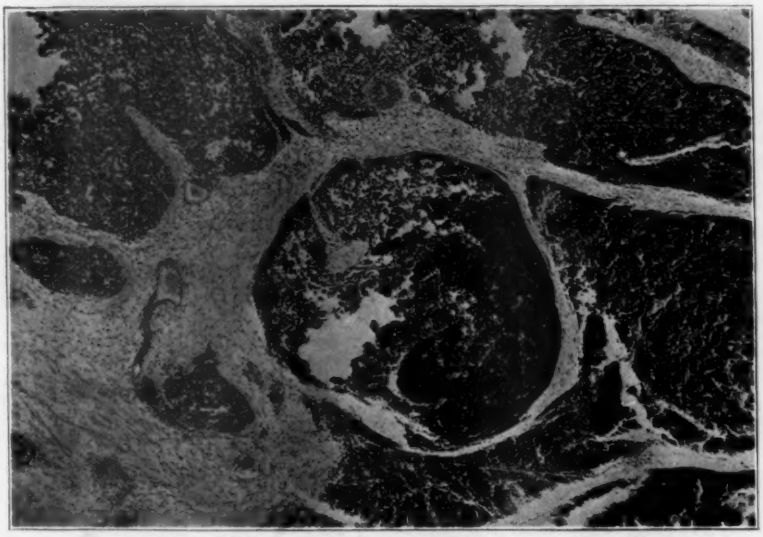

Fig. 16.—The formation of septums in Ewing's sarcoma, giving it an alveolar arrangement (no. 24667, tables 2 and 4).

There appeared to be no intercellular stroma, but a fibrous trabeculation with a hyaline-staining intercellular substance divided the tumor tissue into lobules where it infiltrated the soft parts. These septum formations often gave the tumor an alveolar arrangement (fig. 16).

Vascularity was a variable feature of these tumors; in some it was marked (fig. 17). In certain sections taken through areas of bone, haversian canals, occupied by blood vessels, were secondarily infiltrated by tumor cells (fig. 18). In these localities, the tumor cells were sometimes within and sometimes without the vessel walls. Phenomena of this character have been cited by some authors as evidence of the seat of origin of Ewing's sarcoma. We are inclined to the belief, however, that, in most of these instances, tumor cells were traversing the haversian system, following the path of least resistance in their invasion of bone.

Areas of osteitis fibrosa,[16] either subperiosteal or endosteal in origin, were seen where the tumor was invading bone. Here osteoid spicules were found, surrounded by osteoblasts and fibrous tissue (fig. 19), the new bone thus formed being typical of the process described by us as occurring in bone cysts and giant cell tumors. This reaction, we believe, is an attempt by the bone to heal itself, in a manner often noted in fractures, by a metaplasia of fibroblasts to osteoblasts and to osteoid tissue.

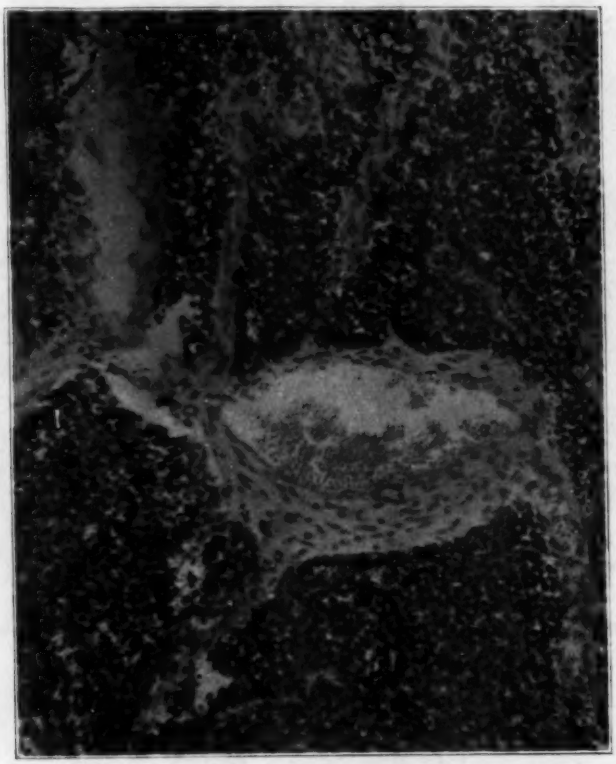

Fig. 17.—A photomicrograph showing blood vessels surrounded by tumor and the infiltration of tumor by hemorrhage. One may note the marked difference between the tumor cells and the cellular elements comprising the blood vessels (no. 35654, table 5).

In some sections, islands of tumor cells with a blood vessel at the center were surrounded by areas of necrosis, the blood supply apparently being inadequate for more than the tumor cells immediately surrounding the vessel. Such necrotic areas were referred to by Kolodny as hydropic degeneration of tumor cells, and by other authors as a peritheliomatous structure.

The periphery of the tumor in many cases was infiltrated by cells of the polymorphonuclear or monocytic types. This infiltration by round cells was most common in the cases of longer duration or in those in which the tumor had previously been explored, and not infrequently had led to an erroneous diagnosis of osteomyelitis at biopsy. Eosinophils were frequently observed along with the round cell infiltration, both of these processes indicating, in all probability, a response to chronic irritation. An infiltration by plasma-like cells was noted in only

Fig. 18.—Note the invasion of haversian canals by tumor. The tumor is extending along the vessel in one haversian canal, while other canals are completely filled with tumor cells.

nine cases of the series. This, possibly, had no special relation to the tumor, as sections of normal bone sometimes show such cells. On finding these cells, certain authors have suggested a relation between this tumor and multiple myeloma.

A peculiar type of cell about the same size as the Ewing sarcoma cell was often observed in these tumors. It contained a small, deeply-staining nucleus, eccentrically placed, and a clear, eosin-staining cyto-

plasm. The locality in which these cells were found related them to the haversian canals, and in such conditions as bursitis we noted them proliferating about the blood vessels in the haversian systems.

DISSEMINATION AND METASTASES

True to the nature of malignant disease, dissemination has occurred in every case of the series which to the time of writing has terminated in

Fig. 19.—A photomicrograph showing osteitis fibrosa surrounding the invading tumor. The osteoid spicules are surrounded by osteoblasts and fibrous tissue (no. 15745, table 5). This osteoid reaction represents the reparative nature of all bone, no matter what the source of the injury.

death. The extent of metastases has been most difficult to localize because of the insufficient data included in many of the case reports, necropsy having been relatively rare in the series. Only those cases in which definite proof of metastases was obtained either by x-ray, biopsy or necropsy are included here, though death in every case was said to have been from tumor.

The most frequent sites of metastases were the lungs, the lymph glands and the skull (see table 2 and fig. 20). The most unique feature in the dissemination was the predilection of the secondary growths for other bones. Although some observers view this dissemination to other bones as proof that the tumor is primarily a multiple disease of the skeleton, in our series it was nearly always possible to obtain a definite latent period of from two and a half months to a year between the initial appearance of the tumor in a single bone and its involvement of other bones.

TABLE 2.—*Primary Lesions with Metastases*

Patient* (Surg. Path. Lab. No.)	Original Location of Tumor	Duration of Symptoms at Time of First Observation, Months	Location of Metastases	Duration of Life Following Treatment, Months
40590	Tibia, lower shaft	4	Skull, femurs, lungs, humeri, scapulae	(Living after 9 mo.)
34422	Tibia, upper shaft	4	Internal organs	53
34344	Femur, lower shaft	5	Humerus	20
32623	Radius, lower shaft	5	Lungs	17
31175	Fibula, midshaft	..	Lungs	16
30944	Tibia, lower shaft	7	Scapula, clavicle	5
30755	Fibula, upper shaft	2	Lungs	10
29054	Tibia, midshaft	..	Skull	22
28835	Femur, lower shaft	4½	Lungs	4½
28774	Ilium	5	Skull	(Died at operation)
28600	Humerus, upper shaft	1¼	Lungs	15
28364	Fibula, upper shaft	2	Lungs, ribs, skull	6½
27511	Femur, lower shaft	6	Lungs, skull, spine	5
26916	Femur	11	Ribs 2, vertebra 1; thrombosis iliac vein	12
26597	Os calcis	24	Lungs	6
25906	Scapula	24	Glands, spine	14
25430	Fibula, midshaft	12	Glands	18
24667	Femur, upper shaft	14	Spine	18
15021	Pelvis	..	Glands	
13439	Humerus, midshaft	5	Glands	14
10537	Tibia, upper shaft	6	Skull	9
5172	Tibia, upper shaft	..	Skull, glands	2
4392	Humerus, upper shaft	3	Glands, internal organs	9
3000	Femur, upper shaft	36	Internal organs	
1207	Tibia, upper shaft	9	Vertebrae	9
64	Humerus, upper shaft	6	Glands, internal organs	5

* These patients were proved to have metastases by x-ray, biopsy or necropsy.

The bones most frequently involved by metastases were the skull, the spine and the scapula or the clavicle, although dissemination to the long pipe bones also occurred. This is well illustrated by the case of a white boy, aged 14, examined in this clinic and later operated on in a neighboring city. This patient, although still alive at the time of writing, has extensive metastases to the skull, the femora, the humeri and the scapulae. The lungs are involved, and he has also become blind, the left eye protruding markedly from its socket. When he was first observed only the tibia was affected.

Enlargement of the lymph nodes was reported in fifteen cases, and in seven cases involvement of the glands was proved by microscopic examination. The lungs were demonstrated to be the seat of metastases in thirteen instances; in many others, pulmonary involvement was evi-

denced by hemoptyses, pain in the chest or a high terminal fever. In four cases, metastases to internal organs were noted without reference to the specific organs involved.

In the clinical picture of Ewing's tumor, the involvement of a single bone early in the disease with later dissemination of the neoplasm to other bones constitutes a unique and important feature setting this tumor apart from other tumors of the bone. In contrast to multiple myeloma or chloroma, it is unusual for the patient to present himself for examination with more than one bone involved; and in such a case, a single focus usually predominates in size, as well as in duration of growth.

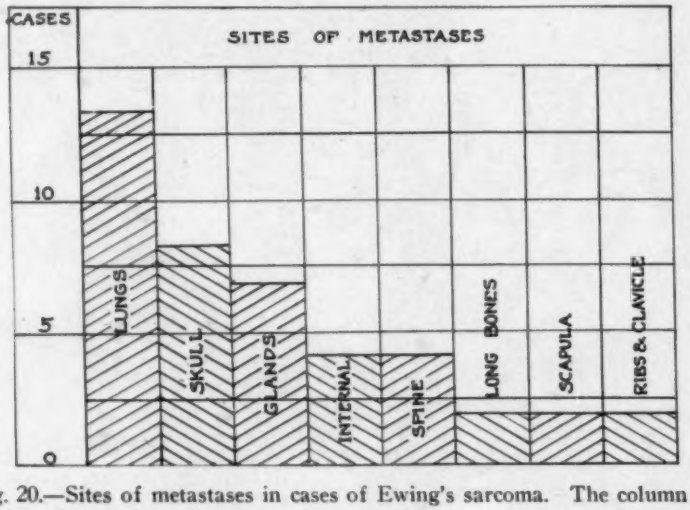

Fig. 20.—Sites of metastases in cases of Ewing's sarcoma. The column to the left shows the number of cases.

CLINICAL COURSE

In order to correlate the early clinical observations with the subsequent course of the disease, a brief turn will be made in survey of the more characteristic features of Ewing's sarcoma, emphasizing the typical course of the disease.

At the onset of Ewing's tumor most often there is tenderness or soreness of the affected part followed by pain of either a dull aching or a sharp shooting quality. The patient's attention is first called to the malady by trauma, spontaneous pain or pain with formation of tumor.

From this initial phase, the patients pass on to a period marked by more continuous pain, and often the nocturnal pain may be the most severe. The intervals of freedom from such attacks of pain become less and less. In many instances, the tumors have a tendency to regress

for a time, leading the patients to think that a cure has been effected, only to recur again, becoming larger in size and accompanied with more severe pain.

The formation of the tumor is often accompanied by some constitutional reaction, expressed in an elevation of temperature to 100 F., on the average, and with localized redness and swelling of the subcutaneous tissue or dilatation of the peripheral veins.

Fig. 21.—A case of Ewing's sarcoma in the femur, which is not unlike the early stage of inflammatory disease of bone.

On examination, a tumor is usually palpated, which varies from a small localized swelling in some cases to a large fusiform mass in others, and which is apparently continuous with the sheath of the bone. The soft parts over the tumor, in most cases, are freely movable, although they may be somewhat edematous and inflamed. The majority of the cases presented an indurated mass, not, however, of bony density, with occasional slight crepitus due to the osteophytes in the tumor of the soft parts.

The x-ray examination usually reveals a diffuse lesion on the shaft side of a long bone. The involved region is widened by periosteal and endosteal formation of new bone, and there may be considerable subperiosteal tumor. The marrow cavity is either narrowed or mottled by reactive bone, and occasionally one sees in a subperiosteal tumor spicules of new bone at right angles to the cortex, although the usual picture is a laminated formation of bone extending along the shaft in parallel

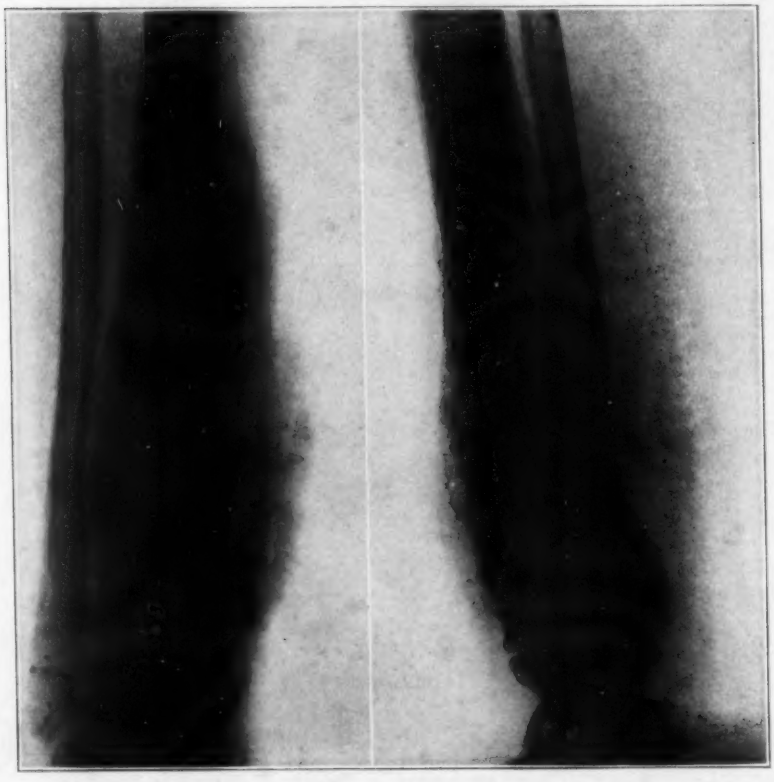

Fig. 22.—Pyogenic osteomyelitis involving the lower end of a tibia. The involucrum is distinct and the shaggy periostitis is a noteworthy diagnostic point.

fashion. In no case is the epiphysis primarily involved, although in late lesions it may be secondarily affected, with evidence in the shaft above of destruction of bone in the medullary and cortical regions.

The red cell count ranges from a normal count to that of a moderate secondary anemia with or without leukocytosis. The average leukocyte count is 15,000. The differential count, in the majority of instances, is within normal limits.

In many cases, the patient gives a history of normal activity for a year or more before being confined to bed. Pathologic fracture is extremely rare. It was noted only three times in this study.

In two thirds of the cases, the course of the patient's health was downward, although temporary relief was obtained by operative proce-

Fig. 23.—A low-power photomicrograph showing osteomyelitis of bone with a healing bone reaction surrounding fibrous tissue. An x-ray picture of the same case is shown in figure 24.

dures. The usual termination is with metastases, but the time of their appearance is difficult to determine accurately because of the paucity of clinical data covering this point.

Loss of weight and secondary growths in other bones, often in the skull and the spine, are frequently seen late in the disease, with an occa-

sional paraplegia. Hemoptyses, thoracic pain and fever are terminal manifestations. In eight cases in this series life was greatly prolonged and an apparent cure effected by radical operation and irradiation, the length of life, at the time of writing, having been from twenty months to nine years after operation.

Fig. 24.—Chronic sclerosing osteomyelitis. There is a periosteal reaction above the metaphysis. As nothing in the history helped toward a diagnosis, an exploration was necessary to rule out sarcoma. A photomicrograph is shown in figure 23.

DIFFERENTIAL DIAGNOSIS

Many patients with disease of the bone are now coming under observation at a relatively early stage of their disease, thus making the differential diagnosis, especially by x-ray, more difficult and more important. A careful survey of the clinical history with every available laboratory procedure is often necessary to differentiate Ewing's sarcoma from other lesions of bone.

Among the many diagnoses first made and later revised in cases of Ewing's tumor filed in the Surgical Pathological Laboratory, it is interesting to note that the diagnosis of inflammatory disease of the bone predominates. A primary diagnosis of pyogenic periostitis or osteomyelitis [19] was made in ten cases, tuberculosis of the bone in nine cases,[20] syphilitic periostitis or osteomyelitis in six cases,[21] and typhoid osteomyelitis in one case, thus showing the frequency with which Ewing's tumor is confused with chronic inflammation of the bone.

Fig. 25.—A tuberculous humerus showing marked destruction in the epiphyseal end of the bone, with involvement of the joint.

Often the intermittent pain, in many cases following trauma, in other cases occurring spontaneously, with some constitutional response, makes for a diagnosis of osteomyelitis. The roentgenogram may not be unlike that of inflammatory disease of the bone (fig. 21), and the biopsy may further substantiate the diagnosis, the surgeon not having gone deep

19. Bloodgood, J. C.: A Brief Summary of Benign and Malignant Lesions of Bone, Southern M. J. **19**:541, 1926.

20. Knaggs, R. L.: The Inflammatory and Toxic Diseases of Bone, New York, William Wood & Company, 1926, p. 57.

21. Bloodgood, J. C.: Differential Diagnosis of Periosteal Lesions, Radiology **3**:432, 1924.

enough to reach intact tumor cells but having removed only a peripheral portion of the tumor infiltrated with mononuclear cells and some fibrous tissue.

Ewing's sarcoma is more often confused with subacute and chronic pyogenic osteomyelitis than with the acute form. As was pointed out by Starr,[22] the acute form of osteomyelitis, in the majority of instances, occurs between the ages of 2 and 10; and because of its sudden onset with malaise, nausea, high fever, rigors, localized boring pain and a leukocyte count of from 25,000 to 30,000, should not often be confused with Ewing's tumor, especially when a primary focus of infection can be demonstrated.

The chronic forms of osteomyelitis commonly show suppuration, except sclerosing osteomyelitis (Garre's type), which shows suppuration in about 10 per cent of the cases;[23] whereas Ewing's sarcoma shows this only in the extreme case or after a previous operation. In the roentgenogram of osteomyelitis an involucrum is commonly seen, but practically never appears in the roentgenogram of Ewing's tumor. This, together with the usual shaggy periostitis and varying degrees of definite destruction of bone (fig. 22), is a noteworthy diagnostic point in chronic osteomyelitis. Biopsy shows the characteristic infected tissue with healing bone surrounding a fibrous zone (figs. 23 and 24).

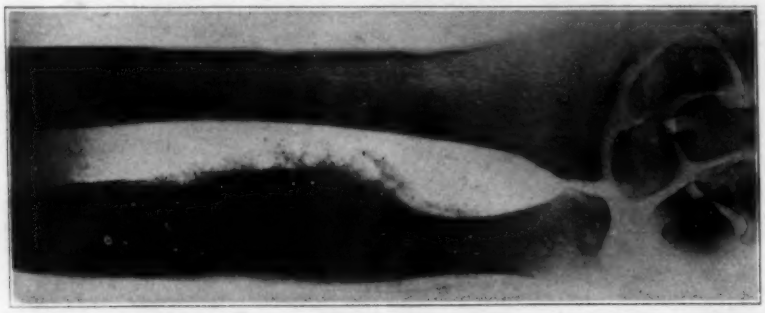

Fig. 26.—A syphilitic lesion in the shaft of an ulna. There is considerable formation of bone beneath the periosteum. Osteophytes extend at right angles to the cortex inwardly from the periosteal region. Similar reactions are seen in malignant tumors of bone.

Tuberculosis of the bone,[24] in contradistinction to Ewing's sarcoma, is most frequent about the upper part of the femur, though it often

22. Starr, Osteomyelitis, in Lewis: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, 1927, vol. 2, p. 4.

23. Bloodgood, J. C.: J. Radiol. **1**:147, 1920.

24. Coley, W. B.: The Differential Diagnosis of Sarcoma of the Long Bones, J. Bone & Joint Surg. **10**:420, 1928.

occurs in other locations. The age does not help in diagnosis of tuberculous disease of the bone, but the underdeveloped and undernourished condition of the patient and the slow progress and lack of severity of the symptoms, together with the longer period of activity, are salient features. The pain in tuberculosis of the bone may be completely relieved by immobilization, in contrast with the increasingly severe pains without relief in Ewing's sarcoma. The x-ray picture of a tuberculous bone usually shows marked destruction in the epiphyseal end of a bone, with

Fig. 27.—A syphilitic lesion in the shaft of an ulna showing destruction of bone with little formation of bone. The usual reaction in this disease, however, is an increase in the density of the bone with formation, in many instances of exostoses.

involvement of the joint and calcification of the soft parts (fig. 25). These are rarely seen in Ewing's tumor, which practically never shows the sequestrums and draining sinuses observed in tuberculosis.

Syphilitic disease of the bone, with which Ewing's sarcoma is often confused, is more likely to occur in later life. The constitutional reaction may not be unlike that of the small round cell sarcoma. Syphilitic

periostitis affects particularly the superficial bones [25] (tibia, clavicle, sternum, ulna, etc.), and usually there is multiple involvement. The periosteum may be bulged, and a formation of small bony spicules, arranged perpendicularly to the cortex of the bone, may occur (fig. 26). Kolodny [12] and Eising [18] pointed out that this perpendicular arrangement of osteophytes is sometimes found in low grade chronic infections of bone, pyogenic or tuberculous. This observation is noteworthy, for radiating spicules perpendicular to the cortex in a bony lesion are com-

Fig. 28.—A case of multiple myeloma of the tibia and fibula showing typical punched-out areas. The other bones involved in this case were the spine, sacrum, skull and many of the long pipe bones.

monly associated with a malignant process of bone, Ewing's tumor being no exception. The cortex in syphilitic disease of the bone may be eroded, and medullary destruction may occur (fig. 27), but exostoses and increased density of the bone are more constant observations. The Wassermann reaction is therefore all important in the differential diag-

25. Chenelot, E.: Sur les gommes syphilitiques simulant des sarcomes, Thèse de Lyon, 1910. Stokes, J. H.: Modern Clinical Syphilology, Philadelphia, W. B. Saunders Company, 1927, p. 685.

nosis and, as was pointed out by Bloodgood [21] and others, when a positive Wassermann reaction is present, a therapeutic test should be carried out before the tumor is explored.

Clinically, multiple myeloma was noted as a source of confusion in two of these cases of Ewing's sarcoma. In a recent publication,[15] we pointed out that multiple myeloma occurs for the most part in persons between the ages of 40 and 70. This is in contradistinction to the age incidence in Ewing's sarcoma, which ranges between the ages of 6 and 20. Multiplicity of tumor was an outstanding feature in over 90 per cent of the cases of myeloma, including involvement of the thoracic cage; skeletal deformity occurred in 60 per cent, and pathologic fracture in 63 per cent of the cases. Bence-Jones bodies were excreted in 65 per cent of the cases. In Ewing's tumor, multiple involvement is rarely seen when the patient first comes under observation; fractures occurred in

Fig. 29.—An osteogenic sarcoma involving the lower end of a femur. There is formation of new bone in the periosteal region, with osteophytes arranged both irregularly and at right angles to the cortex. This type of invasion practically never gives the extensive, laminated new bone paralleling the shaft seen in Ewing's sarcoma. The medullary cavity is encroached on by sclerosing tumor.

only 5 per cent of the cases, and Bence-Jones bodies were never found in the urine. The x-ray picture rarely showed the multiple, punched-out areas seen in multiple myeloma (fig. 28).

The osteogenic sarcoma [26] in the average case is located at the end of the long bone, whereas Ewing's sarcoma appears in the shaft and does not involve the epiphysis. The formation of new bone in osteogenic sarcoma shows right-angled spicules early in the disease and practically never gives the extensive, laminated new bone paralleling the shaft seen in Ewing's sarcoma (fig. 29). There is an occasional exception in osteogenic sarcoma in which there is involvement of the shaft,

26. Nicholes, B. H.: Roentgen Diagnosis of the More Important Tumors of the Long Bones, Surg. Gynec. Obst. **35**:301, 1922.

with little formation of bone (fig. 30). Irradiation of the tumor offers a good therapeutic test. The Ewing tumor responds promptly to irradiation, whereas osteogenic sarcoma is little affected.

Metastatic carcinoma [27] is not infrequently confused with Ewing's sarcoma, both clinically and in some cases microscopically. Carcinoma occurs later in life than Ewing's tumor, the majority of metastatic tumors in bone appearing after the age of 45. A thorough survey of the body for a primary focus often reveals the source of the metastases, thus ruling out Ewing's tumor. An x-ray picture of a metastatic carcinoma in bone usually shows a single medullary lesion

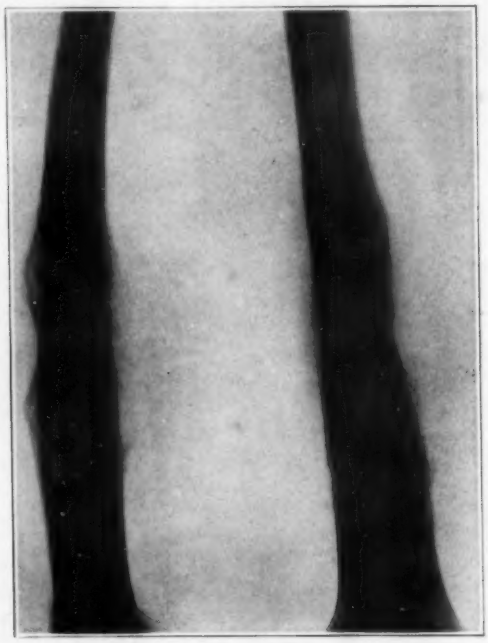

Fig. 30.—An osteogenic sarcoma involving the shaft of a femur with destruction of bone and some new formation of bone. There is considerable periosteal reaction. This may be contrasted with figure 29, showing a common type of osteogenic sarcoma found near the end of long bones, which is sclerosing in nature.

destroying the bone at the site of the nutrient artery. Formation of bone of the healing type is observed in metastatic tumors from the prostate, etc.[28] Kaufmann,[29] in a statistical study, pointed out such a

27. Joll, C. A.: Metastatic Tumors of Bone, Brit. J. Surg. **11**:38, 1923.

28. Simpson, W. M.: Diffuse Vertebral Metastasis of Prostatic Carcinoma Without Bony Changes, Am. J. Roentgenol. **15**:534, 1926.

29. Kaufmann, E.: Lehrbuch der Pathologie, Berlin, G. Reimer, 1911, vol. 2, p. 759.

variation in this type of tumor, and the work of Simpson [30] enabled us to make a complete study of metastases to bone. The frequency of metastases to bone in cases of carcinoma is set forth in table 3.

Sacro-iliac strain and rheumatism were also noted as mistaken diagnoses in our series. An x-ray picture usually reveals the true status of the lesion.

TREATMENT AND PROGNOSIS

The treatment, as outlined here, is based on the observations of Bloodgood [31] and further supported by the analysis of the cases presented here.

In cases in which metastases have not occurred, amputation for lesions of the lower extremity below the upper third of the femur, and resection of bones for lesions in the upper extremity, followed by postoperative irradiation, offer more hope of cure than does irradiation alone. It was recently pointed out that such is the case in all diffuse and periosteal malignant lesions of bone.

TABLE 3.—*Frequency of Metastases to Bone in Carcinoma*

Type of Carcinoma	Cases	Percentage Showing Bony Metastasis
Prostate	24	66.0
Hypernephroma	14	56.0
Breast (in Gross, cited by Neal and Robnett: Arch. Surg. **14**: 529 [Feb.] 1927)	423	20.5
Rectum	57	10.5
Esophagus	101	6.9
Thyroid	55	5.4
Uterus	159	3.0
Stomach	309	2.5

If the lesion occurs in the upper part of the femur or has become so extensive in the upper extremity that the operation of choice is not warranted, irradiation should be resorted to and continued in therapeutic doses until amputation becomes a necessity to relieve pain.

When the lesion is considered operable and the clinical picture, roentgenogram and other laboratory observations are such that sarcoma cannot be ruled out, immediate operation is advised if a competent pathologist is at hand. Never perform a biopsy and wait for a diagnosis from other laboratories. If in doubt, take an x-ray, put the affected part at rest and send the x-ray picture and the history of the case to a competent authority for interpretation. The object of the operation is to explore and to get a piece of tissue for frozen section [32] (neutralized

30. Simpson, W. M.: Primary Thyroid Carcinoma Simulating Hypernephroma, Ann. Clin. Med. **4**:668, 1926.

31. Bloodgood, J. C.: Bone Sarcoma, Periosteal and Diffuse Type, and Their Diagnosis from Benign Lesions, J. Bone & Joint Surg. **8**:727, 1926.

32. Terry, B. T.: A Rapid Method of Examining Tissue Microscopically for Malignancy: Preparation of Polychrome Methylene Blue, J. Path. & Bact. **30**:573, 1927.

polychrome methylene blue stain is used in this laboratory). If the lesion is malignant, the operation of choice based on the site of the lesion must be performed immediately to preserve the life of the patient.

The responsibilities of physicians are steadily increasing, as more and more patients come earlier for diagnosis, making the x-ray picture, the gross appearance and the frozen section more difficult to diagnose. Complete studies with careful follow-ups are the ultimate solution of problems in diagnosis of early bone lesions.

At present, we have complete follow-up reports on fifty-two cases of Ewing's sarcoma. In forty-three cases the patients are dead and in eight cases (18 per cent) the patients are living and apparently well at the time of writing. Every patient who is reported well in this series

TABLE 4.—*Treatment by Resecction or Amputation with Irradiation*

Patient* (Surg. Path. Lab. No.)	Color	Sex	Age	Location of Tumor	Duration of Symptoms at Time of Operation, Months	Microscopic Observations	Duration of Life Following Operation, Months
37472	W	M	28	Humerus, midshaft	36	Typical	(Well after 35 months)
35882	W	F	6	Tibia, midshaft	6	Typical	26
32623	W	M	11	Radius, midshaft	5	Typical	17
32770	W	M	7½	Tibia, midshaft	18	Typical	16
31775	W	M	22	Fibula, midshaft	..	Typical	16
28600	W	M	11	Humerus, upper shaft	1	Typical	15
27631	W	F	14	Scapula, clavicle	..	Typical	(Well after 84 months)
27069	W	M	9	Scapula only	6	Typical	9
26916	W	M	23	Femur, lower shaft	11	Typical	12
26901	W	M	13	Clavicle only	..	Typical	(Well after 84 months)
25906	W	F	19	Scapula only	24	Typical	14
25430	W	F	10	Fibula, midshaft	12	Typical	18
24667	W	M	11	Femur, upper shaft	14	Typical	18

* There are three patients (23 per cent) in this group well, with an average duration of life of five years and seven months following treatment. Of this number two are living over five years.

has a duration of life of more than five years since the onset of symptoms, and six are living over five years following an operative procedure. The average duration of life is seven years and eight months for the eight cases.

We have divided the methods of treatment into three main groups for analysis: (1) amputation or resection with irradiation, (2) amputation or resection sine irradiation and (3) irradiation alone or with exploratory operation.

In group 1 (table 4) there are thirteen cases with a postoperative duration of life averaging 29.2 months. In three cases in this group (23 per cent) the patients were found to be well with an average duration of life of five years and seven months.

In group 2 (table 5) there are twenty-four cases with an average duration of life of twenty months. In four cases in this group (16.5

per cent) the patients are well and have an average duration of life (at the time of writing) of six years.

In group 3 (table 6) there are eight cases with an average duration of life of twenty-seven months. In one case of this group (12.5 per cent), the patient is living fifty-three months after treatment. This patient's lesion was curetted prior to irradiation.[33]

Coley's toxins apparently have had no effect on the duration of life, whether given alone or with other forms of treatment (table 7). There were three patients in the entire series who were given Coley's toxins.

TABLE 5.—*Treatment by Resection or Amputation Without Irradiation*

Patient* (Surg. Path. Lab. No.)	Color	Sex	Age	Location of Tumor	Duration of Symptoms at Time of Operation, Months	Microscopic Observations	Duration of Life Following Operation, Months
35654	W	M	24	Tibia, midshaft	12	Typical	11
34422	W	M	10	Tibia, midshaft	4	Typical	53
34005	W	M	19	Humerus, lower shaft	84	Typical	(Well after 30 months)
32174	W	M	16	Femur, midshaft	6	Typical	7
29286	W	F	12	Tibia, upper shaft	12	Typical	(Well after 78 months)
28835	W	M	24	Femur, lower shaft	4½	Typical	4½
28397	W	F	12	Humerus, upper shaft	9	Typical	(Well after 72 months)
28326	W	M	25	Fibula, lower shaft	9	Typical	1
28364	W	M	13	Fibula, upper shaft	3	Typical, from report	6½
27511	W	M	14	Femur, lower shaft	6	Typical	5
26915	W	M	16	Metatarsal only	..	Typical	36
26885	W	F	44	Tibia, upper shaft	4	Typical, from report	24
26597	W	M	39	Tarsal only	24	Typical	6
24927	W	M	6	Tibia, upper shaft	18	Typical	13
22795	W	M	22	Femur	24	Typical	(Well after 108 months)
15921	W	F	..	Pelvis only	..	Typical	(Died at operation)
15838	W	M	21	Humerus, midshaft	5	Typical	13
15745	W	F	14	Femur, upper shaft	18	Typical	5
7963	W	M	13	Fibula, midshaft	12	Typical	4½
7657	W	M	16	Fibula, midshaft	6	Typical	11
5172	W	F	11	Tibia, midshaft	..	Typical	2
4392	W	F	17	Humerus, upper shaft	3	Typical	9
1207	W	F	8	Tibia, upper shaft	9	Typical	9
64	W	M	21	Humerus, upper shaft	6	Typical	5

* There are four patients (16 per cent) in this group who are well, averaging six years' duration of life after treatment. Of this number three are living over five years.

From a study of these three tabulations there is seen to be little choice between the employment of irradiation (fig. 31) or radical operation. The evidence indicates that the patient should receive a combination of both treatments when the tumor is observed in the usual location prior to metastasis.

In arriving at elements in the clinical history which would be of value in making a prognosis, an analysis was made of the features presented by the living patients. Their ages ranged from 12 to 30

33. Coley, W. B., and Coley, B. L.: Primary Malignant Tumors of the Long Bones, Arch. Surg. **13**:779 (Dec.) 1926; **14**:63 (Jan.) 1927.

years. The site of involvement was either the lower or the upper extremity, including the pectoral girdle. The x-ray picture showed either destruction of bone or formation of bone and sometimes both. It also disclosed diffuse involvement of the bone, and either a parallel or a right angle periosteal reaction. The gross pathologic changes were not unique, and both normal white cell counts and leukocytosis with

TABLE 6.—*Treatment by Irradiation Alone or by Irradiation with Exploratory Operation*

Patient (Surg. Path. Lab. No.)	Color	Sex	Age	Location of Tumor	Duration of Symptoms at Time of Treatment, Months	Microscopic Observations	Duration of Life Under Treatment, Months
35014*	W	F	23	Tibia, midshaft	48	Typical	(Well after 53 months)
34344	W	F	17	Femur, lower shaft	5	.....	20
32910*	W	M	17	Tibia, midshaft	12	Typical	59
31988*	W	M	17	Femur, upper shaft	2	Typical	39
30944*	W	M	20	Tibia, lower shaft	7	Typical	5
30755*	W	M	12	Fibula, upper shaft	2	Typical	10
10537*	W	M	17	Tibia, upper shaft	6	Typical	9
5927*	W	M	7	Femur	2½	Typical	2

* The lesions of bone in these patients, with the exception of three, were explored; in three the lesions were curetted and in one the tumor was treated with radium alone. One patient (12 per cent of the group) is still living 53 months after treatment.

TABLE 7.—*Part 1: Exploratory Operation Alone*

Patient* (Surg. Path. Lab. No.)	Color	Sex	Age	Location of Tumor	Duration of Symptoms at Time of Operation, Months	Microscopic Observations	Duration of Life Following Operation, Months
34027	W	M	23	Ilium alone	11	Typical	1
33807*	W	F	22	Mastoid alone	4	Typical	6
30828	W	F	9	Humerus, upper shaft	13	Typical	4
30072	W	F	21	Ilium alone	5	Typical	9½
29054*	W	M	7	Tibia, midshaft	..	Typical	22
28774	W	F	34	Ilium	5	Typical	1 day
				PART 2.—*Treatment by Coley's Toxins Alone*			
13439*	W	M	23	Humerus, midshaft	..	.....	14

* The glands were excised and showed metastases microscopically typical.

fever were observed. Radical operation with or without irradiation and irradiation alone were among the methods of treatment.

All of the patients reported in this series as living today had a preoperative duration of symptoms averaging twenty months, as against six months for those who died within a year following operation. The shorter duration of symptoms apparently therefore, indicates a more rapidly growing tumor and is ground for a grave prognosis. This reflects seriously on the hope of cure through early diagnosis and early treatment in a definite group of these cases. Apparently, symptoms do not always precede the fatal stages of the disease by a sufficient margin for the purposes of therapeutics.

Exploration does not necessarily affect the prognosis in cases in which radical operation or x-ray treatment follows exploration. In two cases (25 per cent) in which the patients are living over five years, exploration was done before the operation of choice was resorted to. In one case of curettement followed by irradiation, the patient is living over four years after treatment. In six cases in which an exploratory operation was performed without further treatment, death occurred in from one to twenty-two months. In one case in which Coley's toxins alone were given, the patient died fourteen months after the therapeutic procedure was begun.

Fig. 31.—*A* shows the involvement of a tibia by Ewing's sarcoma with much periosteal reaction and a mottling of the marrow cavity. This tumor was explored for biopsy, the exploratory operation being immediately followed by irradiation. *B* shows the effect of irradiation on the tumor. Marked sclerosis has occurred in both the shaft and the periosteal region, reactive bone having been formed in abundance on retardation of the growth of the tumor (no. 32770, table 4).

NATURE OF EWING'S TUMOR

Successful analysis is dependent on a complete series of accurate observations, summarized and recorded in such fashion that connections between related facts become illumined. In order to arrive at some conception of the nature of Ewing's tumor, we have attempted such a summary in table 8.

The facts listed in table 8 point to the conclusion that Ewing's tumor is a malignant sarcoma of bone. In favor of this is the age incidence of the tumor, its location in bone, the cellular nature of the

pathologic changes, the metastases and the high percentage of fatality. Against the opinion, occasionally voiced, that this lesion is a metastatic tumor arising primarily outside of bone is the failure to demonstrate such a primary focus in any of the cases studied and the occasional cures by amputation. The cellular morphology of this tumor also does not resemble that of carcinoma, nor does the age of the patient suggest such a disease.

Opinion in favor of bone sarcoma is therefore substantiated by this study. However, the summary of the observations in table 8 is against the belief that the tumor is a myeloma originating in the marrow cavity. In the first place, as pointed out elsewhere in this paper, the

TABLE 8.—*Summary of the Observations in Cases of Ewing's Sarcoma*

Observations Simulating Tumors in General	Observations Characteristic of Ewing's Sarcoma	Observations Simulating Malignancy in General
Pain and swelling	95 per cent of cases in persons under 25 years of age	Fatal in 87 per cent of cases
Limp	Duration of symptoms to time of treatment, 11½ months	
Fever, leukocytosis	Trauma in from 30 to 40 per cent five months previously	Moderate anemia
Dilatation of superficial veins	Occurrence only in bone	Fever
Tender, firm mass	Tibia most frequently involved	Metastases to the lungs
Occasional regression	In long bones, shaft only primarily affected	Terminal cachexia
	Epiphysis involved only secondarily	Very cellular tissue
	Elliptical area of the shaft involvement	
	Cartilaginous bone primarily involved	
	Bulk of the tumor subperiosteal	
	Subperiosteum usually intact	
	Reactive bone both endosteal and subperiosteal	
	Cortex expanded and thickened	
	Infiltration of bone but not destruction or formation of bone primarily	
	Rapid diffusion	
	Destruction of bone late	
	Pathologic fracture rare	
	Metastases to membranous and cartilaginous bone	
	Predilection of metastases for skull	
	Tumor cells uniform in size, oval or round	
	No tumor giant cells	
	No Bence-Jones bodies in the urine	
	Regional glands involved	
	Conclusion:	
	A neoplasm originating during the growth period in the diaphysis of bones, rapidly infiltrating bone, with early diffusion, invoking both periosteal and endosteal reaction, but producing no tumor bone or direct erosion of bone	

elliptical area of shaft involvement with the bulk of the tumor lying subperiosteally does not resemble the usual central and spherical contour of medullary tumors. Multiple myeloma, metastatic carcinoma and chloroma with leukemia all show a central location with a more or less spherical growth widening the medullary cavity. These tumors occupying the marrow cavity show early destruction of bone and with the majority of them in at least isolated instances, Bence-Jones bodies have been demonstrated.[15] The Ewing tumor, in contrast with these neoplasms, most frequently shows a narrowing or occlusion of the medullary cavity with both endosteal and subperiosteal formation of new bone early in the disease, which would seem to indicate that the tumor has not a primary medullary origin. The absence of marked

changes in the blood and of Bence-Jones bodies in the urine is against this assumption. Gross specimens and microscopic sections cut transversely through the bone usually show only a small portion of the tumor tissue in the marrow cavity. The rapid extension of the Ewing tumor in a plane parallel to the axis of the shaft indicates that the tumor has not the privilege of expanding freely in the two opposite directions and points to the growth's being either intracortical or subperiosteal in origin.

The majority of the observations summarized in table 8 could be explained by either an intracortical or a subperiosteal origin of the tumor. If the neoplasm is primary in the haversian systems, this would explain the rapid infiltration by the tumor, producing both early endosteal and subperiosteal reactions of new bone. It would explain, also, the distribution of the tumor under the periosteum and into the medullary cavity in the later stages, and account for the widening of the haversian canals and the splitting of the layers of the cortical bone so frequently observed under the microscope (fig. 32). However, conclusive microscopic proof of the origin of the Ewing tumor in the haversian canals is lacking. While specimens usually show the tumor pervading these structures, we have been unable to determine whether the tumor arises here or secondarily infiltrates into these channels.

The assumption that the Ewing tumor arises in a subperiosteal locality may be maintained, with probably equal validity, from the facts observed. The active subperiosteal layer which ceases at the epiphysis and atrophies in adulthood would account for the involvement of the shaft only, in youthful patients. This locality would account also for the fact that the bulk of the tumor is under the periosteum, for the tendency of the haversian systems to be infiltrated, and for the reactive formation of new bone of both endosteal and subperiosteal origin. It would explain also the tendency of the tumor to extend up and down the shaft rather than to form a spherical growth. It would also fit in with the absence of Bence-Jones bodies in the urine and the lack of marked changes in the blood.

On the basis of these observations, it is clear that the tumor, whether primarily intracortical or subperiosteal is not medullary, nor primarily osteolytic, as is currently believed. The rarity of pathologic fracture, the localities affected, the x-ray and the gross observations are all against the assumption, and destruction of bone is always a late manifestation in the disease (fig. 7).

The suggestion of Kolodny, following the lead of Ewing, that the tumor arises about the perivascular lymphatics in the haversian canals is not altogether unfeasible and would give this tumor an intracortical origin. Tumor cells are frequently observed in this region (fig 33), but sections of normal bone do not show cells of the Ewing type from

which the neoplasm might arise. While we observed proliferation of cellular elements about these lymphatics in bone beneath such a condition as bursitis, the cells were of a different type and the endothelium of the lymphatics did not appear to us to resemble the Ewing cell. We

Fig. 32.—A low-power photomicrograph of a section taken through the body of the scapula. Note the splitting of the layers of cortical bone, the widening of the haversian canals and the spicules of bone at right angles to the cortex extending inwardly from the region of the periosteum. There is a small nest of tumor cells in the medullary cavity, but the bulk of the tumor is between the cortex and the reactive bone of the periosteum near the point of medullary involvement (no. 27039, table 4).

reviewed the endotheliomas of the soft parts with all the sarcomas of the soft parts in this laboratory and did not find a tumor duplicating

in cellular character the Ewing sarcoma. The endotheliomas in the collection of Dr. A. R. Rich in the department of general pathology, which he has gathered from the uterus, the testicle, the peritoneum, the duodenum and the liver, and the endotheliomas in our own collec-

Fig. 33.—A photomicrograph showing a portion of the cortex of a bone. The haversian canals have been widened by the infiltration of tumor, which has pervaded the bone by means of the perivascular lymphatics within the haversian canals (no. 32174, table 5).

tion which resemble these, differ markedly from Ewing's sarcoma of bone. We believe that the "osteolytic endothelial myeloma" of Ewing is not primarily osteolytic or medullary, nor is it endothelial, although we grant the specificity of the tumor and find that the sixty cases

reported here resemble those described by Ewing, Connor and Kolodny, both clinically and microscopically.

The facts at our disposal do not enable us to point out either the site of origin or the histogenesis of this tumor, and while we believe that the primary focus is specific for bone and is probably intracortical or subperiosteal, we prefer to leave the matter sub judice.[34]

CASE REPORTS

CASE 1.—*History.*—R. N., aged 19, white, a cashier was admitted to the Johns Hopkins Hospital on March 26, 1920, complaining of a lump on the left shoulder blade. She had suffered the usual ailments of childhood. The family history and the patient's previous history were otherwise noncontributory. The present illness began with a fall in February, 1918, while the patient was playing basket-ball. She struck the ground with the upper part of her back. For ten days she noticed an aching and a tired feeling in this region, but no sharp pain, swelling, tenderness or restriction of motion. In February, 1919, the patient noticed soreness in the upper part of the left arm, and at the same time the development of a lump 4 by 5 cm. in diameter on the superior and medial angle of the left scapula. She did not observe any elevation of temperature or tenderness of the affected part. In May, 1919, the lump suddenly increased, and a sharp, shooting pain radiated from the region of the lump to the hand and fingers. The lump became exquisitely painful for three or four days, and then suddenly diminished in size. The pain and tenderness ceased, and the patient again felt well. Other similar attacks occurred without fever in August, September and December of 1919. On March 12, 1920, the lump suddenly increased and became exquisitely painful and tender. In this condition, the patient was admitted to the hospital.

Physical Examination.—The patient was a healthy-looking girl of 19 years, well developed and well nourished. The mucous membranes were of good color. A review of the systems was essentially without important result save for the left scapula, where over the supraspinous part a tumor was found, 10 by 12 by 2 cm., with normal overlying skin. The tumor was a smooth, saucer-shaped mass overlying and attached to the supraspinous portion of the scapula, and extending above and medial to the superior border. The lump was not fluctuant and not tender. The blood count revealed the hemoglobin content to be 78 per cent and the white cells 7,300. The urine was essentially normal. Bence-Jones bodies were not reported. X-ray studies were made, and a diagnosis of sarcoma was considered.

Clinical Course; Treatment.—On April 10, 1920, while the patient was in the hospital, it was deemed advisable to resect a portion of the scapula. The neck of the scapula was left intact to articulate with the head of the humerus. The patient made an uneventful recovery and returned home. On Sept. 29, 1920, the patient was readmitted to the hospital, this time with a slight elevation of temperature. The patient, after going home, had steadily grown weaker. An aching pain had developed in the left shoulder following an injury to the affected part four

34. Studies are now under way to determine the exact nature of the tumor. From the radiologist's point of view Ewing's sarcoma responds like a tumor of the lymphoid group in that it reacts readily to irradiation. This is in contradistinction to the endotheliomas, which react little, if any. Histologically also the cells resemble the lymphoblast. Differential stains are being worked out to fortify further, if possible, the position that Ewing's sarcoma may be of lymphoid nature.

weeks prior to admission. The tumor had reappeared and was rapidly growing. Treatment with radium was deemed advisable.

On May 21, 1921, the patient died. Before death, she had dwindled to a mere skeleton, was practically paralyzed, and was having severe attacks of pain about every seven hours.

Gross Pathologic Changes.—The specimen consisted of the medial five sixths of the scapula. A tumorous mass involving the middle half of the superior margin, together with the supraspinous fossa and subscapular fossa was noted. It was fairly circumscribed, although not encapsulated. Along the advanced margin, the tumor appeared between the periosteum and the bone. On section, the surface was a clear gray with a few yellow opaque areas. The medullary cavity appeared to be less involved. No hemorrhagic areas were seen, and grossly there was little stroma; nor were trabeculae involving the tumor areas observed.

Microscopic Observations.—Much fibrous stroma, with areas of small, round and ovoid cells, the nuclei of which varied slightly in size was noted, with little or no intercellular stroma. The cellular structure was typical of Ewing's tumor. Bone spicules were noted, most of which were being destroyed by tumor cells. An area of periosteum was seen with a layer of new bone formed beneath it, which in places was separated distally from another layer of bone by tumor cells.

CASE 2.—*History.*—L. J. W., aged 34, white, a housewife, was admitted to Johns Hopkins Hospital on July 14, 1921, complaining of trouble with the back and the hip. The family history was noncontributory; the patient's previous history revealed an attack of phlebitis in the left leg following the birth of a child, about a year before admission. In 1909 and again in 1915, tonsillectomy was performed, and the patient had had the right antrum drained in 1915.

The illness in question began in September, 1920, with a pain in the region of the coccyx, especially on walking. She limped with the right leg and for two months previous to admission had suffered sharp pains in this limb on movement, accompanied by a sensation of "giving way" in the lumbar region.

Physical Examination.—There was pain on pressure over the right sacro-iliac joint. The fifth lumbar vertebra was more prominent than usual. All deep reflexes were slightly hyperactive. X-ray examination revealed a large area of destruction in the ilium involving the sacro-iliac joint. The sacrum was not involved, and apparently there was no bony reaction surrounding the area of destruction. The blood count showed white cells 6,500 and red cells 4,160,000, with a hemoglobin content of 90 per cent. Polymorphonuclear cells were 64 per cent. The urine was normal. Bence-Jones bodies were not reported.

Treatment and Clinical Course.—The patient was put in a brace and discharged to return in six weeks. On Aug. 30, 1921, she returned to the hospital because of a wrench of the back; she was suffering intense pain. The physical examination revealed nothing more than had been noted before. The laboratory observations were again within normal limits. On Sept. 7, 1921, a swelling the size of a walnut was noted attached to the skull just to the right of the midline on the anterior portion of the head. The nodule was slightly sensitive. X-ray pictures showed two small areas of destruction in the parietal bone. On Sept. 8, 1921, an exploratory operation was done. The right ilium was exposed, the fascia covering the sacro-iliac joint was opened and a considerable amount of clotted blood escaped. At one point, the bony pelvis was apparently eroded through. The patient left the operating room in a state of shock, and died on Sept. 9, 1921. At no time was there an elevation of the temperature.

Microscopic Observations.—A homogeneous mass of small round cells with slightly vesicular nuclei was noted. The chromatin content of the nuclei was moderate with no particular arrangement. There was little connective tissue framework, and the tissue was not vascular, only a few blood vessels being noted.

CASE 3.—*History.*—W. H. R., aged 17, white, a machinist, was admitted to the Johns Hopkins Hospital on April 27, 1910, with a complaint of swelling and lameness in the right leg. The family history and the patient's previous history were noncontributory. The illness had begun six months previous to admission, when the patient noted intermittent pain in the right leg. The pain persisted for about two days and then disappeared for about two weeks. The intervals between the attacks of pain became shorter until four months before admission; then the patient began to have pain in the right leg every night. The pain was piercing, and prohibited sleep. Five months before admission, swelling was noted at the site of the pain, and two months before admission, the swelling was curetted at a neighboring hospital. The wound, which exuded serosanguineous fluid for a time, finally healed. Shortly after the operation, the pain recurred, the patient having many wakeful nights. The patient ceased to walk because of a painful right knee. Subsequent to the onset of his illness, he noticed a loss of weight amounting to 15 pounds (6.8 Kg.).

Physical Examination.—The physical examination revealed a poorly nourished boy. The right inguinal glands were enlarged and hard, but there was no enlargement of the glands in general. The right leg, thigh and knee were distinctly larger than the left. A fusiform swelling below the knee was noted. A scar 10 cm. long was seen over the upper part of the right tibia. On palpation, the tibia appeared thickened, but fairly smooth; nowhere was it fluctuant. Over its upper portion, tenderness was easily elicited. Voluntary motion of the leg was good. Laboratory examination revealed: white blood cells, 12,000; red blood cells, 6,000,000; hemoglobin 65 per cent; polymorphonuclears, 75 per cent. The urine was normal. No Bence-Jones bodies were reported.

Treatment and Clinical Course.—Coley's toxin was given from time to time as a postoperative measure, and x-ray treatment was administered twice weekly for a time. The temperature was elevated on admission, and at no time later was it noted as normal; it reached 103 F., excluding the reactions caused by Coley's toxin. The patient died on Nov. 2, 1910, with metastases to the skull and to the glands of the groin.

X-Ray Observations.—The x-ray picture showed a definite periosteal formation of new bone resembling somewhat that seen in syphilitic periostitis or in the involucrum about a chronic osteomyelitis. Between the bone shadow and the periosteal growth there were more light shadows than one expects in x-ray pictures of syphilis or of osteomyelitis. The shadow of the medullary cavity of the upper third of the tibia was irregular.

Microscopic Observations.—Areas of small round cells were surrounded by fibrous stroma. There were also areas of old bone and hemorrhage. There were numerous cavities chiefly in the cellular areas. In places, the fibrous stroma was cellular, while in other areas the fibrous stroma had a marked amount of eosin-staining intercellular substance.

CASE 4.—*History.*—J. B., aged 10, white, a school girl, was admitted to the Johns Hopkins Hospital on Dec. 6, 1919, complaining of intermittent pain in the leg. The family history and the patient's previous history were noncontributory. The present illness began about one year before admission to the hospital with cramps in the lower part of the left leg, not severe, and lasting for only a short

time, with recurrences several months apart. Two weeks before the patient's admission, the mother noticed that the child's left leg was a little larger than the right leg, and she immediately sought medical consultation.

Physical Examination.—The results of physical examination were negative at this time save for the condition of the affected part. The left calf was distinctly enlarged, especially at the outer side. On palpation, a mass was felt along the fibula extending from 6 cm. below the knee to 6 cm. above the external malleolus. It was fusiform, reaching its maximal size at the region of the calf. The tumor mass was bony, not tender but immobile, and the surface was apparently rough. The inguinal glands were hard and shotty on both sides, but more so on the right. There was no elevation of temperature locally over the tumor mass. The blood count showed: white blood cells, 9,860; red blood cells, 4,864,000; hemoglobin, 75 per cent; polymorphonuclears, 62 per cent. The Wassermann reaction was negative. The urine was normal. Bence-Jones bodies were not sought for.

Treatment and Clinical Course.—On Dec. 11, 1920, the fibula was excised together with the area of tumor. The leg was then irradiated. The patient made an uneventful postoperative recovery and returned home. On Aug. 1, 1928, the patient was readmitted to the hospital for large and painful glands of the left groin, the glands being the size of hickory nuts. At this time, the edge of the liver was felt 3 fingerbreadths below the costal margin, although the lungs were apparently normal. The lymph glands were removed and on section were found to contain tumor. The leg was irradiated at Dr. Howard A. Kelley's Hospital, but the clinical course was continually downhill and the patient eventually succumbed with diffuse internal metastases. After the patient's admission to the hospital, the temperature ranged from 99.4 to 100 F.

Gross Pathologic Observations.—The specimen consisted of the lower two thirds of the fibula, which contained a tumor mass. The periosteum was thickened above and below the mass and appeared to be continuous with the capsule surrounding the tumor. The bone was eroded as though worm eaten, and the bony trabeculae were seen running at right angles to the shaft into the subperiosteal tumor mass. The tumor was well circumscribed by the attenuated periosteum.

Microscopic Observations.—The tumor was composed of much fibrous tissue surrounding areas of round and ovoid cells of uniform size. The cytoplasm of the cells was indistinct, staining a pale pink with eosin. An occasional area of old bone was seen surrounded by tumor cells. Giant cells were not seen.

CASE 5.—*History.*—W. S., aged 21, white, was admitted to the Johns Hopkins Hospital on Oct. 21, 1913, complaining of a swollen left shoulder. The family history and the patient's previous history were nonessential. The present illness had begun five months prior to admission with a small lump in the left shoulder which gradually grew until it had reached considerable size. For the last three months before admission the shoulder had been painful both day and night, but the nocturnal pain was the more severe. There was no history of trauma.

Physical Examination.—Examination revealed nothing of interest save at the site of the lesion. Over the head of the left humerus was a large, almost spherical swelling roughly as large as an orange. It was everywhere smooth and indurated but not bony. On palpation, it appeared to be directly continuous with the sheath of the humerus. There was definite atrophy below the elbow joint. There was no general or local elevation of the temperature.

The blood count showed: white blood cells, 11,600; hemoglobin, 87 per cent; polymorphonuclears, 52.8 per cent. The urine was normal. Bence-Jones bodies were not sought.

Treatment and Course.—On Oct. 28, 1913, resection of the upper end of the humerus was done with a subsequent transplantation of bone. Early in 1914, amputation was performed. The patient died from the tumor in September, 1914.

Microscopic Observations.—Although sections are not available at the time of writing, Bloodgood, in a recent classification, placed this tumor microscopically in the Ewing sarcoma group.

CASE 6.—*History.*—J. F. B., white, aged 22, was admitted to the Johns Hopkins Hospital on Jan. 8, 1918, complaining of pain and swelling in the region of the left knee. The family history and the patient's previous history were noncontributory. The present illness had begun two years before admission with pain, which was more or less persistent. One month later, a swelling was noted in the region of the right knee. Six months prior to entry, the patient joined the army, his condition having been overlooked. Six weeks prior to hospitalization, the patient consulted an army surgeon because of pain in the knee on riding a horse.

Physical Examination.—Examination revealed nothing of importance save a swelling above the knee surrounding the lower end of the femur. On palpation, an irregular, hard mass was felt, but there was no tenderness or edema of the soft parts. The glands in the left groin were larger than normal. The popliteal artery was easily palpated over the tumor mass. There was some limitation on flexion of the joint.

Treatment and Clinical Course.—Soon after admission of the patient to the hospital, the involved leg was amputated just below the trochanter of the femur; the glands in the groin were removed. The patient at the time of writing has remained well, without irradiation, for nine years following the operation.

Gross Pathologic Observations.—The specimen consisted of the greater part of the femur, which had been sectioned longitudinally. The lower part of the femur was encircled by a periosteal growth, largest on the posterior side of the femur, with considerable thickening of the cortical bone. There were spicules of bone radiating out into the tumor at right angles to the cortical bone (fig. 7). The deeper or intercortical surface, the cancellous bone and marrow cavity appeared grossly normal.

Microscopic Observations.—The tumor was composed of small round cells arranged in large alveoli, separated by dense fibrous tissue. In the tumor cells, many cross and longitudinal sections of thin walled blood vessels containing blood were noted. Bone lamellae were observed within the fibrous tissue between the areas of tumor cells.

CASE 7.—*History.*—M. R., white, aged 8, a school girl, was admitted to the Johns Hopkins Hospital on Jan. 17, 1896, complaining of an injury with subsequent tenderness and swelling of the upper part of the left leg. The family history and the patient's previous history were noncontributory. The present illness had begun nine months before admission, when the patient fell on the left leg. It became tender for a few days and then apparently was well. Three months before the patient's admission, the mother noticed a swelling in the anterior portion of the lower part of the child's leg, and the child complained of some pain that was much worse at night. The tumor gradually increased in size, occasionally regressing, only to become again somewhat larger.

Physical Examination.—The patient was a well nourished girl, presenting nothing abnormal save at the site of the lesion. Over the upper third of the left tibia, a swelling was noted apparently not involving the head of the bone. The swelling was firm and tender; the skin was normal, except for the increase in the size of peripheral vessels and slight edema in the region of the tumor mass. The

temperature of the patient while she was in the hospital, ranged between 98.6 and 100 F. The blood count was within normal limits. The urine showed no abnormality.

Treatment and Clinical Course.—Amputation was performed soon after the patient's admission. Eighteen months after the injury, nine months after the operation, the patient showed metastases to the cervical vertebrae, and subsequently succumbed to the tumor.

Gross Pathologic Observations.—A periosteal growth began at the middle of the tibia and extended to the epiphyseal line. The periosteum was thickened but not perforated. The tumor showed a fine, grayish-white, granular growth containing spicules of bone. The shaft of the bone was invaded by the growth. There was little formation of new bone and considerable destruction of bone.

Microscopic Observations.—The tumor was composed of small round cells, some of which were arranged in small alveoli. The compartments of cells were separated by strands of fibrous connective tissue.

CASE 8.—*History.*—I. C., white, aged 6, was admitted to the Johns Hopkins Hospital on Aug. 20, 1919, complaining of pain in the left leg. The family history was noncontributory. The patient had suffered an injury to one leg (side not mentioned) at the age of 1½ years; otherwise the history was without bearing. The illness in question began one year before admission, with pain in the left leg and a slight fever. There was no redness or swelling over the surface of the leg. The fever subsided in a few days, and there was no further trouble until Aug. 13, 1919. Then the lower part of the left leg became red, swollen, painful and hot.

Physical Examination.—Examination revealed a white boy, with a slight general glandular enlargement. Results of the general physical examination were otherwise negative except for the condition at the site of the lesion. The left leg was swollen from the knee to a point just above the ankle. The overlying skin was tense but not reddened. There was no increase in surface temperature. On palpation, a firm, indurated mass, not tender and not fluctuant, was noted in the region of the left tibia, apparently continuous with the sheath of the tibia. An x-ray picture showed a lesion similar to syphilitic osteomyelitis. The temperature during the period of admission ranged between 99.4 and 101 F. Laboratory observations were not reported in this case except for the urine, which was normal. Bence-Jones bodies were apparently not sought. The white cell count was 13,000.

Treatment and Clinical Course.—The patient died of tumor in September of 1920, one year and one month after the operation.

Microscopic Observations.—The tumor was composed of small, round and oval cells staining a uniform deep blue. No nucleoli were seen in the nuclei, and little or no cytoplasm was found. There were numerous small blood vessels traversing the section of the tumor.

CASE 9.—*History.*—W. L. G., white, aged 20, a laborer, was admitted to the Johns Hopkins Hospital on April 6, 1907, complaining of pain about the coccyx. The family history and the patient's previous history were noncontributory. The present illness had begun seven months before admission with trauma to the right hip, a slight pain having been felt in the coccygeal region for a short time previously. The pain became more frequent after the trauma. Four months before admission, it became constant, and concomitantly the patient noted a beginning lameness with the formation of a tumor in the region of the hip. He also noticed a loss of 20 pounds (9 Kg.) in weight over a comparatively short period of time. Defecation and urination became painful.

Physical Examination.—The patient was a young white man with considerable loss of subcutaneous fat. The glands in the neck and in the groin were enlarged. The results of the general physical examination were otherwise negative, except for the condition at the site of the lesion. On the dorsum of the right ilium, a smooth, hard, round swelling extended to the right margin of the sacrum. The blood and the urine showed nothing of unusual interest. There was no record of Bence-Jones bodies. Previous to admission an exploratory operation had been performed at a neighboring hospital. On admission to the Johns Hopkins Hospital, the condition was found to be inoperable, and only enough tissue was removed for diagnosis. This patient was not heard from subsequently.

Microscopic Observations.—The tumor was composed chiefly of small, round cells of the Ewing type. In places, these cells were separated by bands of eosin staining fibrous tissue. Here and there we saw hemorrhage and coagulation necrosis. Giant cells were not seen.

Case 10.—*History.*—S. H., a white man, aged 24, was admitted to the Johns Hopkins Hospital on Nov. 3, 1892, complaining of pain in the upper part of the left arm. The family history and the patient's previous history were noncontributory. The illness had begun in May, 1892, six months prior to admission, with pain in the left deltoid region, which at times was severe, with aching and throbbing. Two and one half months before admission, following a strain of the left arm, swelling began and gradually increased with, at the same time, extreme tenderness on pressure. There was edema of the lower part of the arm and of the hand, which remained constant after the swelling in the arm had become noticeable.

Physical Examination.—The results of the examination were negative save for the affected limb, which showed a swelling in the middle third of the humerus extending to and above the shoulder joint and into the axilla. The skin over this tumor mass was edematous and red. The blood and the urine at this time were normal. Bence-Jones bodies were not reported.

Treatment and Clinical Course.—On Nov. 3, 1892, an exploratory operation was performed, and a diagnosis of sarcoma was made. Amputation at the shoulder joint followed a few days later. Metastases to the glands were found in the axilla at this time. Death occurred a few months later from internal metastases.

Microscopic Observations.—The tumor was composed of small, round cells, well preserved about the blood vessels, in places, with peripheral necrosis, while in many areas one found masses of tumor cells with no particular arrangement. Strands of fibrous tissue were seen dividing the tumor into compartments. Spicules of bone were undergoing absorption surrounded by the tumor cells.

Case 11.—*History.*—M. C., white, aged 17, a housewife, was admitted to the Johns Hopkins Hospital on Aug. 20, 1902, with a complaint of pain in the upper part of the right arm. The family history and the patient's previous history were noncontributory. The illness had begun three months before hospitalization with pain between the elbow and the shoulder of the left arm. There was no history of trauma. A concomitant swelling the size of a hen's egg appeared in the same region. The swelling was first poulticed, later aspirated and then, six weeks later, incised, a blood clot being removed. The tumor grew rapidly following the incision. One week before admission, the skin over the tumor became bluish and edematous. Another incision was made, and this had not healed at the time of admission. The pain was intermittent and of varying severity; it usually was a dull shooting pain. There was considerable edema of the right forearm at times.

Physical Examination.—The patient was well nourished, and apparently in the best of health, except for pale mucous membranes. The affected limb revealed a fusiform tumor a little below the middle of the upper part of the right arm, over which, in part of its extent, a scar and an ulcerated area were found. The tumor mass was apparently firmly attached to the humerus; it was not tender and not painful. The temperature following admission ranged from 99 to 100 F. The urine revealed nothing of interest. Bence-Jones bodies were not reported. The hemoglobin content of the blood was 75 per cent.

Treatment and Clinical Course.—On Aug. 22, 1902, the arm was amputated at the shoulder joint. The patient made an uneventful recovery. A few weeks later, some enlarged axillary glands were removed, which showed metastases. The patient apparently did well for a time. Then there was a gradual recurrence in the stump. The patient became emaciated, the area of the right breast became involved, and the patient died of tumor nine months after the operation.

Gross Pathologic Observations.—A spindle-shape tumor surrounded the shaft of the humerus. The shaft was roughened. In the tumor tissue between the shaft and the periosteum, there were islands of bone of irregular shape, and the cylinder-like blood vessels were filled with blood clot. The greater part of the tumor was so hemorrhagic that its character could not be made out. The nonhemorrhagic portion was pearly white, finely granular and friable. The entire tumor was encapsulated from the surrounding muscles.

Microscopic Observations.—The tumor was composed chiefly of small, round or elongated cells, with no giant cells. In places, a perithelial arrangement could be made out. There was a great deal of hemorrhage between the cells, and there were large vessels filled with blood.

CASE 12.—J. H. C., white, aged 24, a farmer, was admitted to the Johns Hopkins Hospital on March 19, 1899, complaining of pain and discomfort in the right leg. The family history was of interest only in that it revealed considerable tuberculosis in the family. The patient's history previous to the illness was negative. The illness in question had begun three years before with trauma of the right leg. The same leg was retraumatized one year later, when the patient fell and fractured the right femur. There was no swelling or other evidence of tumor, and the leg was treated for simple fracture. But apparently the leg did not heal. Nine months before admission, an operation was performed and much macerated tissue and about a quart of stained fluid was removed from the affected limb. Subsequently an amputation was performed. The patient had become emaciated and weak, but after the operation he gained in weight and was about on crutches until one week before the admission under consideration. Then the stump was aspirated and an amount of bloody fluid was removed.

Physical Examination.—The patient was poorly nourished and emaciated, but otherwise apparently normal, except for the right stump. This was enlarged and swollen, with many dilated veins at its distal portion. The line of incision was normal. The tumor mass in the region of the stump was hard, resilient and uniform throughout. The surface, was smooth. There was good motion in the hip joint.

Treatment and Clinical Course.—On March 24, 1900, the leg was amputated at the hip joint, and the iliac glands were excised. One month later, there was a local recurrence, with clinical manifestations of internal metastases. The patient succumbed to the metastases. The temperature during the period of admission had ranged within normal limits.

Gross Pathologic Observations.—An encapsulated tumor almost completely filled the amputated stump. Nothing was left of the bone but the articular car-

tilage of the head of the femur. The tumor was composed of a meshwork of fibrous tissue, in the cavities of which was seen friable, hemorrhagic, granular tissue. Much destruction of bone was noted, but no formation of new bone.

Microscopic Observations.—The infiltrating border of the tumor was composed chiefly of small, round and elongated cells with typical nuclei (containing a sparse scattering of chromatin granules). The tumor cells were arranged around cavities filled with blood; in some spots, the perivascular arrangement was beautifully preserved. No pleomorphism was observed, and no intercellular stroma was noted. Septums divided the tumor into lobules, a phenomenon often seen in soft parts invaded by the tumor.

CASE 13.—*History.*—P. S., white, aged 11 years, a schoolgirl, was admitted to the Johns Hopkins Hospital on Nov. 23, 1903, complaining of a tumor of the left leg. The family history and the patient's history previous to the illness were noncontributory. The illness had began six months prior to admission, when the patient received a trauma of the lower part of the left leg and another slight trauma soon afterward. At that time, soreness developed in the bruised portion of the leg, which became swollen and looked much inflamed. There was a slight elevation of temperature. The swelling was progressive; the skin became red and streaked in places. Two months before admission, the leg became painful, the nocturnal pain being more severe than the diurnal pain. On Oct. 1, 1903, a physician was consulted, who advised blistering of the leg. At a later date, he incised the tumor area. Soon after this the pain recurred with increasing severity. Another physician was consulted, who operated immediately, incising the bone. Pain decreased for a few weeks and then returned in a more severe form and remained constant until the admission under consideration.

Physical Examination.—The patient was pale and thin, and had lost much subcutaneous fat. She had a slight enlargement of the glands of the groin. The results of a general physical examination were otherwise negative save for the lesion on the left leg, which showed a spindle-shaped enlargement in the region of the tibia. On its anterior surface, a large mass protruded, appearing ulcerated with much erosion of tissue. The area was covered by a foul-smelling, yellowish discharge.

The blood at this time revealed a leukocyte count of 15,000 with hemoglobin 40 per cent. The urine was normal. Bence-Jones bodies were not recorded. The temperature subsequent to admission ranged from 99 to 100 F.

Treatment and Clinical Course.—On Nov. 24, 1903, the leg was amputated through the thigh region. The patient made an uneventful recovery. However, a few weeks after the amputation, metastatic nodules were noted in the right occipital and temporal regions of the skull, with some spasticity of the extremities. The patient succumbed eight weeks after the operation. An autopsy was not permitted.

Gross Pathologic Observations.—A tumor entirely surrounded the left tibia. The upper portion of the tibia was considerably expanded. The greater part of the tumor was necrotic and dirty, yellowish green, with a foul odor and a cheesy consistency. Those portions of the tumor that were well preserved were soft, and a thick cellular fluid could be scraped from their surfaces. The compact bone was much thinned, and the medullary cavity was filled with material looking like the rest of the tumor.

Microscopic Observations.—A mass of small, round and ovoid cells with indistinct cytoplasm was observed. The nuclei were sparsely granular without any particular chromatin arrangement. There were areas of hemorrhage with an occasional well preserved blood vessel. Formation of new bone was not noted, but old bone was being resorbed.

PANCREATIC BLADDER IN THE DOMESTIC CAT

REPORT OF A CASE *

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While conducting a series of observations on the effect of intravenously injected emulsified fat on the emptying of the gallbladder of cats, we fortuitously encountered a case of pancreatic bladder. Although twenty-three cases of well defined pancreatic bladders have been recorded in the literature during the last twenty-three years, the anomaly is exceedingly rare; it appears only in the domestic cat. Since this is the first time an anomaly of this sort has been observed in our laboratory, and since its structure so satisfactorily supports the hypothesis of a pancreatic origin, we are including the description of the case in the slowly accumulating literature on aberrant pancreatic lobes and vesicles.

Boyden [1] (1925) not only described six new cases of the aberrant variation, but presented for the first time adequate histologic and embryologic data in support of the origin for pancreatic bladders wholly independent of the extrahepatic biliary system. Bean and Dreyer [2] (1927) have added additional histologic data to our knowledge of pancreatic bladders. These authors made a unique contribution in that they showed in their second paper a case of double pancreatic bladder in which a smaller vesicle was embedded in the wall of the primary one. Although they recognized a difference between the gallbladder and the primary pancreatic bladder, yet, in their opinion, the identity of the smaller pancreatic bladder and gallbladder was sufficient to establish an hepatic origin for both vesicles. Boyden [3] (1929), however, showed the error of this conclusion by calling attention to their published illustration, in which clusters of glands lie within the tunica muscularis of

* Submitted for publication, Feb. 15, 1929.

* From the Division of Experimental Surgery and Pathology, The Mayo Foundation.

1. Boyden, E. A.: The Problem of the Pancreatic Bladder; a Critical Survey of Six New Cases, Based on New Histological and Embryological Observations, Am. J. Anat. **36**:151, 1925.

2. Bean, R. J., and Dreyer, N. B.: A Pancreatic Bladder in the Cat, Structurally Analogous to the Gallbladder, Tr. Nova Scotia Inst. Sc. **17**:63, 1927; Duplication of Pancreatic Bladder and Accessory Pancreas in the Cat, Anat. Rec. **36**:155, 1927.

3. Boyden, Edward A.: A Note on the Origin of Pancreatic Bladders, J. Anat. **63**:363, 1929.

the secondary vesicle. Such structures do not exist in the gallbladders of cats, but are common to pancreatic vesicles; thus Boyden concluded that the explanation that these vesicles are of pancreatic origin is still satisfactory. Hitherto, some students of the problem of pancreatic bladders had ascribed to them an origin essentially hepatic, since they were thought to arise through clefts in the gallbladder or extrahepatic tract. Earlier consideration of the anomaly had not included any essential differentiation in the morphology of the hepatic and pancreatic vessels, and they had been regarded as derivatives of one and the same structure, although Miller [4] (1910) had claimed that possibly their origin was from the ventral pancreas. Lewis [5] (1911) ventured the suggestion that pancreatic bladders are really double gallbladders, arising from a subdivided hepatic diverticulum, which empties into subdivided cystic and common bile ducts. In the development of the extrahepatic biliary tract in man, the facts may warrant the assumption that such duplication as does occasionally exist may have its explanation in the double lumen which arises following the solid stage of the bile duct. Double gallbladders and split cystic and common ducts in man, occasionally reported in the medical literature, no doubt have an adequate embryologic explanation. On the other hand, it is extremely difficult to account for these aberrant pancreatic structures in the porta hepatis of the cat on the basis of the embryogenesis of the hepatic diverticulum.

Boyden [6] (1926), in a careful study of the development of the hepatic structures in the cat, could not recognize at any time a solid stage of either the common or the cystic ducts. This is interesting in the light of the fact that cases involving split cystic or common ducts have never been observed in this animal, and is rather conclusive evidence that whatever such splitting does exist in other animals a cleft arising in the solid ductus cysticus or choledochus has occasioned the splitting. The gallbladder in cats, on careful study of the development of the hepatic structures in the cat, could not recognize at any time a solid stage of either the common or the cystic ducts. This interesting in the light of the fact that cases involving split cystic or common ducts have never been observed in this animal, and is rather conclusive evidence that whenever such splitting does exist in other animals a cleft arising in the solid ductus cysticus or choledochus has occasioned the splitting. The gallbladder in cats, on the other hand, possesses these solid stages during

4. Miller, W. S.: Pancreatic Bladders, Anat. Rec. **4**:15, 1910.

5. Lewis, F. T.: The Bi-Lobed Form of the Ventral Pancreas in Mammals, Am. J. Anat. **12**:389, 1911.

6. Boyden, E. A.: The Accessory Gallbladder. An Embryological and Comparative Study of Aberrant Biliary Vesicles Occurring in Man and the Domestic Mammals, Am. J. Anat. **38**:177, 1926.

its embryonic growth for in the 15 mm. embryo the entire lumen, involving both the fundus and the neck, is filled with a solid core of cells proliferated from the simple columnar epithelium. Subsequently isolated clefts arise in this core; at first discontinuous, they ultimately fuse, increase in size and restrict the original core of cells to slender trabeculae, until at the 38 mm. stage the distended form of the vesicle has been restored, and it is hollow throughout. It would appear that the existence of paired ducts and vesicles, as in these pancreatic anomalies, must have an explanation other than that first suggested by Lewis. Were it not for the finer histologic disparity that really does exist between the biliary and the pancreatic bladder, the case of Beckwith [7] (1920), in which the vesicles of the cat are confluent at the necks, might have its explanation in a subdivided hepatic organization. And yet the paired ducts, continuing from their point of confluence independently backward, the one to the choledochus and the other to the ventral lobe of the pancreas, do not have a common origin in the light of newer knowledge of the embryology of this region in the cat. Accordingly, one may only postulate that in the Beckwith case a fistulous communication had been established between the two structures hitherto independent.

In the case of pancreatic bladder under consideration, the two vesicles, as well as their ducts, were entirely independent down to the region of the ampulla, and in this sense is more or less identical to the instance recorded by Mayer [8] in 1815. Pursuant to another study, the cat was killed by a severe blow on the head, and opened and explored immediately. Lying closely adjacent to the gallbladder, and suspended from it by a double fold of mesentery, was this flask-shaped pancreatic vesicle (fig. 1). It was pure white and presented a striking contrast to the dark, bluish-green gallbladder lying just dorsal to it. The vesicle was relatively well distended with a whitish fluid of watery consistence, which could be expressed into the duct readily since the vesicular wall was far less resistant to pressure than the tunic of the gallbladder. With the hypodermic needle the white fluid was withdrawn carefully, tested and found to be pancreatic juice, as judged by its proteolytic action. There was no evidence of bile in the fluid content of the vesicle.

Organic continuity did not exist between the two vesicles at any point. They were more closely adherent, however, at the level of the neck of the gallbladder, where the two vesicles were firmly bound by bands of fibrous tissue; one is forced again to recall the Beckwith case in which a confluence had been established between the two structures at this level.

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7. Beckwith, Cora J.: Note on a Peculiar Pancreatic Bladder in the Cat, Anat. Rec. **18**:363, 1920.

8. Mayer, A. C.: Blase für den Saft des Pankreas, Arch. f. d. ges. Physiol. **1**:297, 1815.

In this case, however, the tunic of one could be readily freed from the tunic of the other; thus the two structures should be recognized as organically distinct, arising from divergent anlagen. It is not altogether improbable that had this animal continued to live for a considerable period a fistulous communication might have arisen between the two structures at this point, thus producing a condition identical to that described by Beckwith.

Below the approximated necks of the two vesicles, the respective ducts diverge somewhat and pursue their independent course to the

Fig. 1.—Liver and duodenum of the cat. The pancreatic bladder (left) is suspended from the larger gallbladder.

duodenum (fig. 1). The choledochus, receiving the hepatic ducts, enters the wall of the duodenum at the customary level and opens by way of the ampulla into the gastro-intestinal tract. The pancreatic duct, on the other hand, enters the anterior extension of the ventral lobe of the pancreas, joins the duct of Wirsung and subsequently unites with the choledochus at the ampulla. In this cat, the ventral lobe of the pancreas extended forward to the level of the pylorus, at which point the duct coming from the vesicle entered pancreatic tissue.

The microscopic evidence in this case of pancreatic bladder entirely substantiates the conclusions of Boyden, and since there is such disparity

between the finer organization of the two vesicles it seems advisable to present this additional data which can hardly be explained on the hypothesis of a "split" gallbladder.

Both pancreatic and biliary vesicles were fixed with formaldehyde and maintained in the approximate state of distention in which they were encountered. Accordingly, the relative thickness of the respective tunics has not been essentially altered by fixation or procedures of technic. Sections were stained with hematoxylin and eosin, and with van Gieson's stain.

Sections taken through the approximate center of the gallbladder, passing through the fundus of the pancreatic vesicle, revealed at once the dissimilarity in the finer organization of the two structures (figs. 2 and 3). True, both of them possess the tissues characteristic of biliary

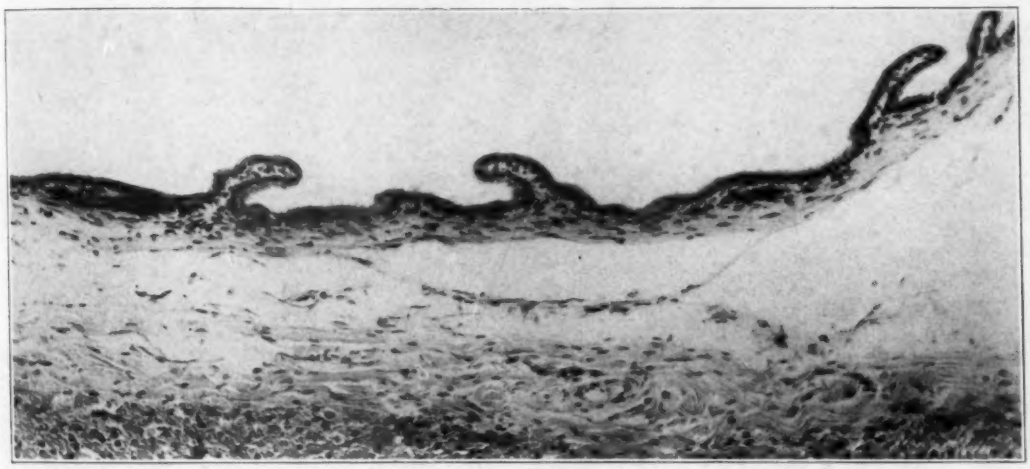

Fig. 2.—Section of the wall of the gallbladder through the approximate center of the vesicle; × 150.

vesicles and both possess rugae of varying proportions, extending into the lumen, but in the finer details the two are essentially different. The wall of the pancreatic vesicle is from three to five times as thick as that of the biliary vesicle, a discrepancy due more essentially to the larger extent of the tunica propria in the former. The folds of the mucosa, extending into the lumen of the pancreatic vesicle, are triple the proportions of those of the gallbladder. In the latter the rugae are of about uniform height, seldom branch and rarely if ever unite at their tips. Even in the greatly contracted gallbladder (Boyden,[9] 1925) the folds

9. Boyden, E. A.: The Effect of Natural Foods on the Distention of the Gallbladder, with a Note on the Change in Pattern of the Mucosa as It Passes from Distention to Collapse, Anat. Rec. **30**:333, 1925.

appear more filiform in section and have only a slight tendency to branch. In contrast, the rugae of the pancreatic bladder are of varying heights and frequently they branch, or become contiguous at their tips, forming thereby enlarged crypts below the mucosa. Furthermore, the cells forming the axes of these folds of the pancreatic mucosa are more loosely arranged than those in the gallbladder, where the tunica propria forms a solid more or less compact structure. Scattered cells, perhaps of the histiocyte series, abound throughout the extent of the submucous coat in the pancreatic vesicle. These could not be recognized in the tunic of the gallbladder.

Cells comprising the mucosa of the pancreatic vessel are of the high columnar type with large spherical nuclei basally placed. The cyto-

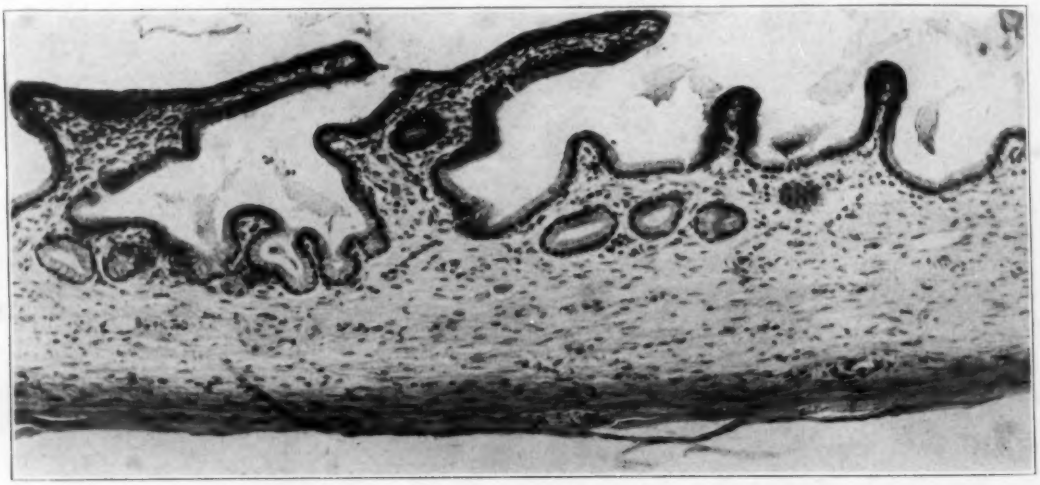

Fig. 3.—Section of the wall of the pancreatic bladder through the region of the fundus; × 150.

plasmic bodies are extensively vacuolated, spongy or alveolar in content and in marked contrast to the granular cytoplasm of the mucosa of the gallbladder. Whether these cells constitute an absorbing or a concentrating mechanism, similar to that in the gallbladder, can only be postulated. The extensive vascularity of the vesicle, however, may suggest that the fluid contents, or portions of it, found its way into the organ by an absorptive route.

As indicated, all layers of the pancreatic vesicle are considerably thicker than corresponding portions of the wall of the gallbladder. Muscle fibers, however, are relatively scarce, and they are intertwined with the elastic fibers of the serosa and cells comprising the tunica propria, so that it is difficult to differentiate muscularis as such.

Adjacent to the muscle cell area is the serosa, consisting of a dense fibrous coat through which the larger vascular channels and the outer peritoneal layer course.

The neck of the two vesicles are equally distinctive in their organization, and apparently the structures are wholly independent in origin. The neck of the pancreatic bladder is simple in structure, and is only a reduction in size of the distended fundus, whereas the neck of the gallbladder resembles in every way that of a normal biliary vesicle (figs. 4 and 5).

The ducts of the two bladders are histologically dissimilar throughout their entire extent and thus constitute further evidence that the structures are organically independent. The pancreatic duct, where it emerges from the portal lobe of the pancreas, is about the size of the choledochus, but does not possess the sinus-like glands, parietal sacculi, which characterize the lining of the biliary duct. In general, the aberrant pancreatic duct in this case resembles normal pancreatic ducts. On entering the portal lobe of the pancreas, the aberrant duct receives ductules of varying size from adjacent pancreatic lobules and empties into the main pancreatic duct which continues to the ampulla at the duodenum.

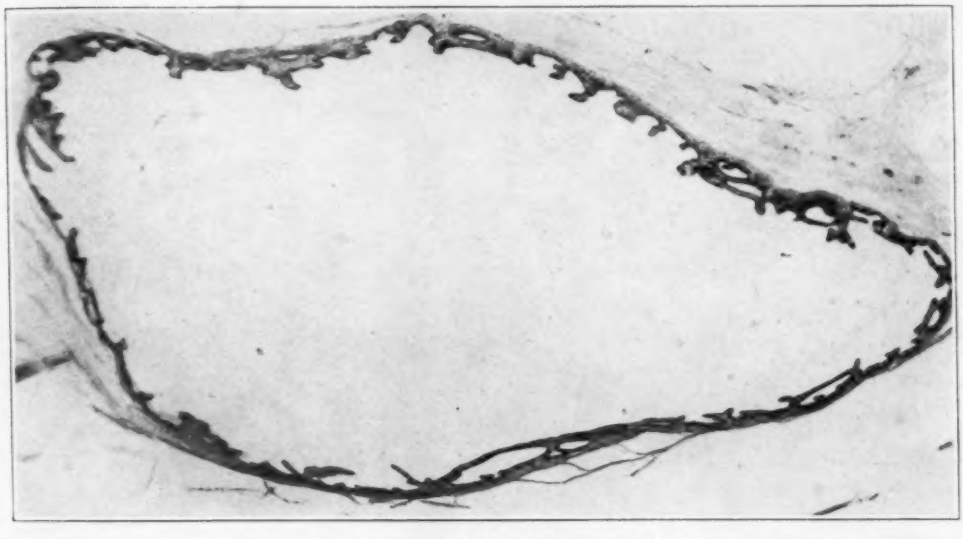

Fig. 4.—Section through the neck of the gallbladder just distal to the valve of Heister; × 45.

COMMENT AND SUMMARY

It seems assured that the relatively high incidence of pancreatic material in the porta hepatis of cats has its explanation in the hepatic

invasion of acinar tissue from the accessory lobes of the ventral pancreas during embryonic development. Although an embryonic ventral pancreas similar to that in the cat develops in the pig, as has been shown (Boyden, 1925), the manner of the subsequent development of the hepatic diverticulum and the hepatic trabeculae rather inhibits the anterior extension of these lobes into the portal area of swine. Accord-

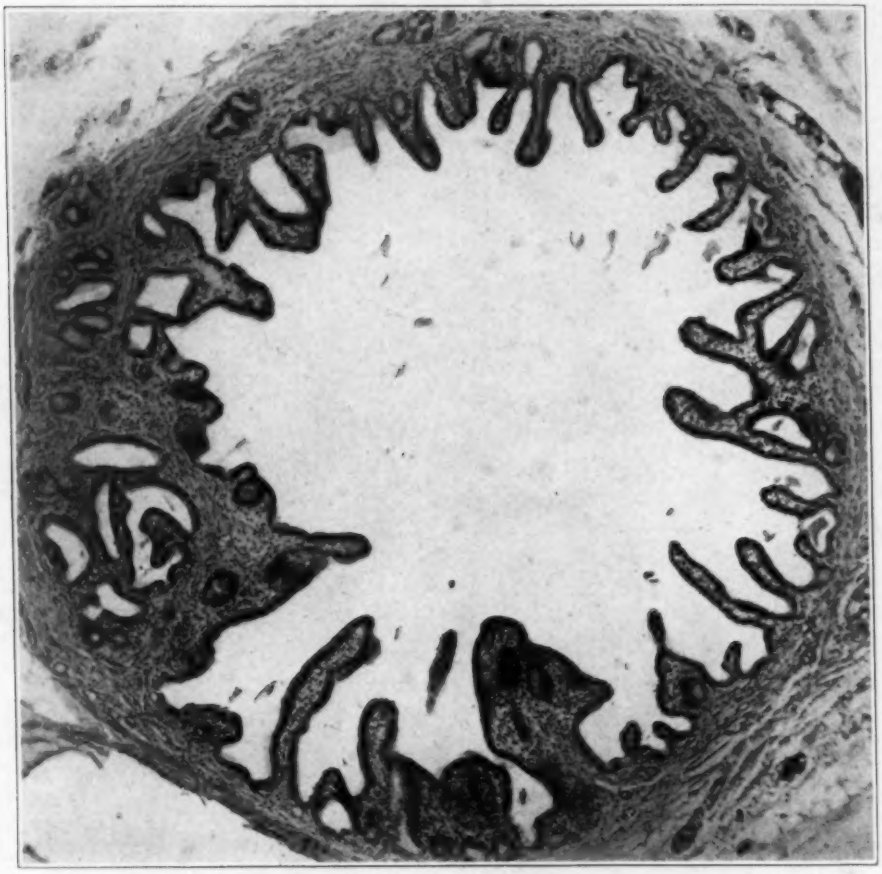

Fig. 5.—Section through the neck of the pancreatic bladder. The contrast between the mucosal patterns of the two vesicles is striking; × 75.

ingly, accessory lobes of the pancreas rarely occur in the porta hepatis in this animal.

In many animals pancreatic tissue occurs occasionally in the hepatic area. Higgins[10] (1926) reported the observation in a dog of an isolated

10. Higgins, G. M.: An Aberrant Pancreas in the Wall of the Gallbladder of the Dog, Anat. Rec. **33**:149, 1926.

pancreatic lobe, buried in the wall of the gallbladder and communicating directly with the lumen of the vesicle. Mann [11] (1920) had hitherto reported a case similar to this one, and since then has had occasion to observe another. Boyden has observed only 3 cases of pancreatic lobes reaching to the gallbladder in 2,600 sheep, and 40 such aberrant lobes appeared in the same number of cats. It seems relatively certain that it is the same type of anomaly in all animals, only more pronounced in certain ones than in others, a fact, no doubt, of embryonic significance. Just why, in certain cases, a lobe persists intact, retaining continuity with the major pancreas, entirely unrelated to the biliary tract, while in others fistulous connections arise between the two, resulting in complete atrophy of intervening portions of the pancreas tissue, are unanswered questions.

The various types of pancreatic anomalies in the portal region appear to fall into three groups, which are more or less indistinctly defined. The first of these involves the existence of a pancreatic lobe which extends into the portal area, frequently as far as the gallbladder, but without fistulous connections with the gallbladder or hypertrophied ducts that could function as a bladder. The second group includes those cases in which a pancreatic lobe has become attached to some part of the biliary tract, into which it continues to pour its secretions. These lobes may have arisen in situ or they may represent fistulous portions of a detached portal lobe. The third group of cases includes those anomalies of pancreatic organization in which the distal portion of the duct draining the ventral lobe has hypertrophied in some way to form a vesicle. Attachment to the hepatic diverticulum has carried these tissues cephalad, and they are found at various positions in the porta hepatis attached to some portion of the liver.

The various anomalies described are understood to be modifications of the same sort, and all are to be explained on the basis of embryonic development. The various cases described, in which the aberrant pancreatic ducts or bladders are confluent with biliary structures, must be interpreted as the result of secondary communications between the two, and not on the basis of the dual concept of the hepatic diverticulum. The histologic distinctions which maintain between the pancreatic structures on the one hand and the biliary structures on the other, which have been described and are confirmed in this study, militate against a common origin for pancreatic and biliary vesicles.

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11. Mann, F. C.: Accessory Pancreas in the Dog, Anat. Rec. **19**:263, 1920.

OCCLUSION OF THE AXILLARY ARTERY DUE TO PRESSURE BY A CRUTCH

REPORT OF TWO CASES *

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It is well known that the prolonged use of a crutch may induce a transitory musculospiral palsy, but damage to the main axillary vessels from the same cause appears to be an exceedingly rare phenomenon. Five years ago, a patient with obliteration of the axillary artery due to pressure by a crutch came under my observation, and several months later, a second patient was seen with an identical lesion. It was believed at first that these cases were probably unique, but later it was discovered that three similar cases had already been recorded: two by Ryle [1] in 1922, and one by Souques and Terris in 1924.[2] More recently, a fourth case has been described by Stricker [3] from the Strasbourg University Surgical Clinic. In view of the undoubted rarity of "crutch thrombosis," it is considered worth while to add the following cases to those already on record.

REPORT OF CASES

CASE 1.—*History.*—T. K., a man, aged 38, was extremely crippled as a result of spastic paraplegia dating from early infancy (Little's disease). He had ultimately learned to walk with the aid of crutches, and in spite of his disability had worked in a useful capacity on his father's farm. Although two crutches were necessary, as a rule, he was able to progress for short distances by resting his whole weight on the left crutch only and swinging his rigid spastic lower limbs forward.

In April, 1924, he noticed for the first time a numbness in the fingers of the left hand. Two months later, owing to pain and weakness in the wrist, he consulted his physician who discovered an absence of pulsation in the radial artery. A week later, absence of pulsation was noted in the brachial artery. The pain on exertion and the sense of weakness in the limb steadily increased.

Examination.—In July, 1924, when I saw the patient, the left upper limb was cold and abnormally pale, more especially in the forearm and hand. Pulsation was completely absent in the radial and brachial arteries, the latter vessel being palpable as a thickened cord. The subclavian and proximal part of the axillary artery showed pulsation equal to that of the opposite side. The skin of the hand

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* From the Orthopaedic Service, Ancoats Hospital.

1. Ryle, J. A.: Guy's Hosp. Rep. **72**:434 (Oct.) 1922.

2. Souques and Terris: Bull. et mém. Soc. méd. d. hôp. de Paris **48**:536 (April 11) 1924.

3. Stricker, P.: Rev. de chir. **65**:617 (July) 1928.

and forearm showed no patches of duskiness or erythema, and there was no trace of edema or distention of the superficial veins. No disturbance of sensation could be demonstrated, and there was no objective evidence of paresis.

The patient was admitted to the hospital for a more complete investigation, which confirmed the absence of cardiovascular disease. A roentgen examination of the cervical spine, shoulder and upper limb revealed no bony abnormality. The Wassermann test was negative. A diagnosis of occlusion of the third part of the axillary artery due to pressure by a crutch was made, and it was assumed that a fairly satisfactory collateral circulation had been established. The patient was warned that the use of a single crutch was dangerous, and was advised to keep the limb warm, to avoid overexertion and to take great care of the skin and nails of the fingers.

Subsequent Progress.—For various reasons the patient could not easily come to the hospital for observation, but occasional reports were received describing his progress. Writing three and a half years later he stated that he now experienced no discomfort in the hand and arm during ordinary use, but that there was an occasional ache after considerable exertion. In his opinion the skin of the limb was normal in appearance, and the limb usually felt quite warm.

Case 2.—*History.*—T. A. A., a man, aged 46, had sustained an attack of poliomyelitis in early childhood. Both limbs were affected, but considerable improvement had occurred in the left leg. The right lower limb remained flail, and for many years a walking appliance had been worn. In recent years this appliance had been discarded, and a crutch on the right and a stick on the left were used instead. In walking no weight was borne on the flail limb, which merely dangled in helpless fashion. In the latter part of 1922, he became conscious of numbness and a feeling of coldness in the right hand and fingers. This gradually became more marked, and later the right arm was noticed to be paler than its fellow. Ten days before the man consulted me, the arm had become very painful, especially when used.

Examination.—In March, 1925, the right arm showed extreme pallor extending from the finger tips to the shoulder region. There was no edema and no distention of the superficial veins. On the middle and ring fingers, there were a few hemorrhagic patches in the skin over the base of the nail but no actual ulceration. The pulse was absent in the radial and brachial arteries. A feeble beat could be felt high up in the axilla, but the subclavian pulse was equal to the opposite side. There were no sensory disturbances, and to objective tests the strength of the hand and forearm seemed undiminished. A diagnosis of occlusion of the right axillary artery due to pressure by a crutch was made. The patient was urged to discard his crutch and to attempt weight bearing on the flail limb with the aid of a caliper splint. The usual precautions for the care of the hand were emphasized.

Subsequent Progress.—When the patient was examined two years later, the hand and arm were found to show a much better color, and the limb could be used freely without discomfort.

COMMENT

In the cases observed by Ryle and by Souques and Terris, the condition of the affected limb at a later date is not recorded. Stricker's case is notable, owing to the development of gangrene in the fingers, a complication that was treated by arteriectomy (Leriche [4]). There are several points of considerable interest in the clinical picture of thrombo-

4. Leriche; and Stricker, P.: Brit. J. Surg. **16**:63 (Jan.) 1929.

arteritis caused by pressure from a crutch. In the first place, the absence of any sign of venous compression is remarkable, for it is well recognized that primary thrombosis of the axillary vein may be produced by a comparatively trivial injury. Gould and Patey,[5] who have recorded eight cases of this unusual vascular lesion, suggested that the thrombosis is the result of the rupture of a delicate valve by pressure of the subclavius muscle when the vein is distended during expiration. How the axillary vein escapes damage from pressure by the crutch is thus not easy to explain.

It is evident that arterial occlusion from pressure by a crutch is ordinarily a gradual process which gives ample time for the development of an efficient collateral circulation. Until compensation is fully established, the subjective and objective symptoms of ischemia (pain on exertion, paresthesia, etc.) are well marked, and for a time there is a risk that trophic ulceration or gangrene may follow. But if the affected limb is protected from further injury and overexertion is avoided, there is every prospect that little or no impairment of function or nutrition will ultimately be demonstrable. This sequence of events is well illustrated in the two cases which form the subject of this paper.

It is further necessary to emphasize the dangers that attend the prolonged use of the ordinary type of axillary crutch, and particularly when the whole body weight is borne by a single crutch. The more careful fitting of crutches in general and the adoption of the "elbow" pattern have undoubtedly made crutch palsy increasingly unfamiliar. These precautions will also tend to minimize the risk of the more serious vascular lesion. Persons with severe residual paralysis of the lower limbs should be provided with efficient walking appliances, and taught to use one or two sticks. The dangling leg and single crutch should never be countenanced.

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5. Gould, E. Pearce; and Patey, D. H.: Brit. J. Surg. **16**:62 (Oct.) 1928.

SUPPURATION IN THE SUBPHRENIC REGION

WITH SPECIAL REFERENCE TO PRIMARY IDIOPATHIC LIVER AND SUBPHRENIC ABSCESS *

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For the purposes of this paper, owing to the similarity in the clinical manifestations of subphrenic and nonamebic liver abscess, these two conditions are considered together, an additional reason being that they are often associated in the same patient and their surgical management is identical.

Any localized collection of pus in contact with the undersurface of the diaphragm is considered by Barnard [1] as a subphrenic abscess. He also included any liver abscess which is near the surface and more or less intimately associated with the diaphragm. This designation appears proper in view of the similarity of the clinical features as presented in the cases of both liver and subphrenic abscess. This similarity is so great in many of the cases as to make a differential diagnosis either difficult or impossible.

A suppurative process in the subphrenic space and liver occurs under a variety of circumstances. Infection usually reaches the subphrenic regions by direct extension or through the lymphatics in such acute abdominal conditions as perforated gastric or duodenal ulcers, acute appendicitis and following operations on the biliary tract. A collection of purulent exudate under the diaphragm, most commonly the right half, is not an uncommon postmortem observation in patients who have died of a diffuse peritonitis of appendical origin or peritonitis from other sources. Patients who recover from a serious peritoneal involvement may at some subsequent time have an abscess in the subphrenic space.

A retrocecal gangrenous appendix may involve the subphrenic area by extension of its infection along the retroperitoneal cellular tissue.

I have found large collections of purulent exudate in the left subphrenic space in two fatal cases of perforated gastric carcinoma and in two others with suppurative lesions of the spleen.

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* Read before the Bronx Surgical Society, April 22, 1929.

* From the Surgical Services of Drs. Henry Roth and L. Miller Kahn.

1. Barnard, H. L.: Brit. M. J. **1**:371, 1908.

Infections in the kidney less commonly give rise to subphrenic abscess. An empyema thoracis is rarely complicated by a subphrenic abscess. In approximately 150 consecutive cases of empyema, I have never observed this complication, nor have I ever discovered it post mortem in fatal cases of empyema.

Beye [2] studied 190 cases of empyema with this association in mind and found one case in which trauma to the diaphragm during operation was probably responsible.

Whipple,[3] in studying 1,000 cases of subphrenic abscess, found that 25 per cent were due to lesions of the stomach, 21 per cent of the appendix, 16 per cent of the biliary tract and 5 per cent of the duodenum, the rest being secondary to lesions of the kidney, spleen, pancreas and lungs.

The liver may become infected from several sources, the avenue of infection being the blood stream or the portal system. Any infective lesion in the gastro-intestinal tract may give rise to liver suppuration, the most common being acute appendicitis. Septic material is transported from a thrombophlebitis of the mesentery of the appendix through the portal vein to lodge in the portal branches where it causes the well known clinical lesion, pylephlebitis. This complicates from 0.1 to 0.4 per cent of all cases of acute appendicitis. In one of my cases pylephlebitis complicated suppurative mesenteric glands. Tropical dysentery is well known as a forerunner of amebic solitary abscess of the liver.

Multiple small hematogenous liver abscesses are not infrequently seen post mortem as part of a grave general infection of the blood stream.

Any septic focus in the body may give rise to a hematogenous transport of a septic embolus with localization in the liver where it may form a solitary liver abscess. One liver abscess of that type developed in a patient with a lung abscess.

Long-standing infection in the common bile duct not infrequently causes an ascending biliary infection, suppurative cholangitis and multiple cholangitic liver abscesses.

Large penetrating peptic ulcers attached to the liver have given rise to suppuration of the liver.

In my cases trauma has not exerted any influence in their development.

Five of the cases reported in this paper were liver abscesses and three subphrenic of the primary idiopathic type differing from those

2. Beye, H. L.: Transphrenic Infection: Report of Ten Cases, Arch. Surg. **14**:240 (Jan.) 1927.

3. Whipple, M. O.: Am. J. Surg. **40**:1, 1926.

alluded to in the foregoing general discussion in that no etiologic basis was found for their existence.

No clinical or postmortem observations were discovered which could be held responsible.

There was no history of biliary disease, appendicitis or any other intra-abdominal lesion. There was no history of dysentery, and evidence of it could not be demonstrated. Amebas were not found in the pus or in the scrapings from the abscess wall.

It appears likely that some cryptogenic infection gave rise to a hematogenous transport of septic material which localized in the liver or subphrenic space.

PATHOLOGY

The type of lesion produced varies with the nature of the primary lesion. In pylephlebitis the liver is large and swollen and on section may show small thrombi in the portal branches or distinct suppuration. If the condition is advanced, there may be liver destruction with multiple coalescent abscesses. If the suppuration is secondary to infected bile passages, the liver is also large, swollen and greenish, and on section the bile channels are found to be distended with a greenish purulent exudate. The end-result is multiple cholangitic abscesses.

In the multiple hematogenous abscesses, the liver is swollen and is the seat of many small scattered abscesses such as those found in the other organs in grave general infection.

The liver abscesses in five cases presented here were large, single and situated in the right lobe of the liver near the surface. In two, it was multilocular and at first gave the impression that they might have been multiple. The abscess wall was unusually thickened and grayish. The content of the abscess was a greenish, purulent exudate, varying from 250 to 1,500 cc. The abscesses appeared as if they had existed for a long period. The liver was much enlarged, and the capsule was thickened, especially that part overlying the abscess. In four of the cases the abscess perforated into the subphrenic space and formed what may properly be called a "subphrenic-hepatic" abscess. In case 5 it perforated the diaphragm and formed a circumscribed abscess between the lower lobe of the lung and the liver. In cases 7 and 8 the abscess was breaking through the lateral chest wall in the lower part. The liver may be intimately associated with the diaphragm and firmly attached to the chest wall, as was present in case 7.

In the primary idiopathic subphrenic abscess, as in the secondary, it may be situated in any one of the six anatomic regions of the subphrenic space described by Barnard. These spaces are right and left anterior intraperitoneal, right and left posterior intraperitoneal and right and left extraperitoneal. The abscesses are usually large and sur-

rounded by a zone of marked inflammatory reaction. In cases coming to autopsy, there was a variety of pathologic changes in the lungs, such as marked fibrosis and moderate dilatation of the bronchioles, especially in the lung corresponding to the side of the subphrenic lesion. Areas of bronchopneumonia and bilateral pulmonary furuncles were seen. The latter were undoubtedly caused by extension from the local seat along the lymphatics or blood stream.

The organisms most commonly found were streptococcus, staphylococcus and colon bacillus. In the secondary type anaerobes are frequently found. In those of my cases in which pleural fluid was aspirated it was found to be clear and straw-colored and revealed the presence of gram-positive and gram-negative organisms on smear but failed to grow when cultured. These organisms were probably attenuated by the bactericidal properties of the same.

CLINICAL AND DIAGNOSTIC FEATURES

Any patient who has had an acute intra-abdominal infection may develop secondary subphrenic or liver suppuration and should be watched carefully for the signs and symptoms of the same.

The secondary subphrenic and liver abscess lends itself more readily to early recognition, especially if the primary condition has recently preceded it. A patient may reasonably be suspected of having pylephlebitis if subsequent to an operation for acute appendicitis he suddenly runs a septic temperature with chills, sweats and jaundice, and has bile in the urine and tenderness over a large liver. The knowledge that such a primary condition not infrequently gives rise to this complication should offer a clue for a search and early recognition. The symptoms of this complication may appear from a few days to several months after the antecedent primary infection. This antecedent disorder may be forgotten or even appear irrelevant to those unfamiliar with the symptoms of this complication.

When a secondary liver abscess or subphrenic abscess develops, the clinical features are similar to the primary idiopathic subphrenic lesion. The primary idiopathic subphrenic and liver abscess or a combination of both offers greater difficulty in their detection because no antecedent lesion is present to offer some clue. A liver abscess constituted an unexpected observation at autopsy in one of my cases in which it was not even suspected.

The onset in the eight primary cases reported here was slow and insidious. There was generalized pain sometimes localized to the chest, an elevated temperature, chilly sensation and a slight cough. Grip was the condition thought to be present in every case by the physician in attendance. After a short period of advised rest, temporary improvement followed. The patients continued in a state of ill health, with

malaise, increasing weakness and elevation in temperature. When the clinical features assumed a more serious aspect, they were referred to the hospital. Pain was the outstanding symptom and was usually located on the side corresponding to the lesion, sometimes in the right or left upper quadrant, in the costal margin or in the lower part of the chest posteriorly. At times the pain was sticking and referred to the right shoulder or to the left in a left subphrenic lesion.

Pain was most pronounced when perihepatitis was most marked. There was a slight cough, usually nonproductive; rusty sputum was never present; jaundice was present in one case. It is more common in pylephlebitis and cholangitic abscesses. It usually draws one's attention immediately to the liver, and in case 4 it was of considerable aid in the prompt recognition of the liver abscess.

Tenderness of varying degree is always present if the lesion has existed for some time.

The patient is case 4 presented marked tenderness and some rigidity in the right upper quadrant. It may sometimes best be elicited by anteroposterior or lateral compression of the lower part of the chest wall. A sense of fulness or a mass and even fluctuation may be detected.

The liver was markedly enlarged in one case in which it was palpated five fingerbreadths below the costal margin. In liver abscesses the liver is usually enlarged, but failure to palpate it may be caused by the fact that the enlargement takes place under the diaphragm, which it pushes upward. When palpated, however, it can be felt below the free border of the ribs.

Edema over the lower axillary part of the chest on the side of the abscess was present in four cases. It generally appears when the lesion is well advanced, and is absolutely characteristic and positive evidence of a subphrenic abscess or a liver abscess which had perforated into the subphrenic space. This sign cannot be depended on in the early diagnosis, as it appears late in the disease.

Examination of the chest revealed various signs such as râles, dulness to flatness, bronchial breathing and diminished fremitus, all of which led to an admission diagnosis of pneumonia or pleurisy with effusion in every case. Eliason [4] reported such diagnostic error in fourteen cases of liver suppuration before a correct diagnosis was arrived at. Pancoast [5] also admitted errors of such nature prior to his familiarity with the roentgen evidence of subphrenic suppuration.

The secondary changes in the chest were so predominant at first as to overshadow completely the exact nature of the lesion, which was not

4. Eliason, E. L.: Surg. Gynec. Obst. **42**:510, 1926.
5. Pancoast, H. K.: Am. J. Roentgenol. **16**:303, 1926.

revealed until the roentgen examination and fluoroscope presented the evidence which is now known to be characteristic of a subphrenic or liver abscess. Until then the roentgen ray confirmed the clinical opinion of a condition of the chest.

The roentgen features of a liver or subphrenic abscess are elevation of the diaphragm and limitation in excursion. The height of the diaphragm varies with the location of the abscess and with its nearness to the dome of the diaphragm.

In case 1 the roentgen signs appeared late because the abscess evidently began low down near the diaphragmatic attachment and reached the dome when the abscess was well advanced. In case 7 the elevation of the diaphragm was slight, because the abscess was perforating externally through the chest wall and away from the dome.

Restricted motion also depends on the extent of the pathologic change. It is more marked in subphrenic than in liver abscess because there is usually greater inflammatory reaction in the former which binds it to the chest wall. In case 4 the lesion was thought to be in the liver, because there was free excursion although the diaphragm was distinctly elevated.

Two cases showed the presence of air with a fluid level below the diaphragm.

It cannot be emphasized too strongly that roentgen examination should be repeated frequently whenever such a lesion is believed to be developing.

Constitutional symptoms were pronounced and became progressively worse until the abscess was drained or until death occurred.

The temperature usually ranged between 100 and 103 F. with an elevation of from 105 to 106 F. The course did not resemble that seen in pylephlebitis except in case 4. If the abscess was well encapsulated, the temperature was of low grade.

Chills or chilly sensation were common. Sweating was a constant and troublesome symptom; in the advanced cases there was profound debility and marked emaciation.

The examination of the blood showed a white count ranging between 13,000 and 28,000 with a high differential count. A marked secondary anemia was present in some cases, necessitating transfusion. The entire attitude was one of great anxiety and grave illness.

A diagnostic puncture of the subphrenic space or liver is advised by some although it appears to be a highly dangerous procedure with little advantage to the patient. It should never be done outside of the operating room, where one should be prepared for immediate operation.

In any case in which one has reason to suspect such a condition it is far safer to explore this territory under local anesthesia in order to establish its presence or absence. Direct palpation and visualization

through this incision will usually yield sufficient information to guide one in the further management of the case.

Case 1 prompted this plan in the absence of more definite evidence. Through a left lumbar oblique incision suggestive pathologic changes in the kidney and perinephric space were excluded. The left extraperitoneal subphrenic space was explored, and a large, apparently inflammatory mass was discovered. The discovery of the mass led to the location of the abscess. Pus even then was obtained with great difficulty and only after several punctures in different areas under direct visualization; but at least it was obtained without danger of infecting foreign territory. In case 6 diagnostic puncture resulted in infection of the pleural cavity which later necessitated an operation for empyema.

TREATMENT

The secondary subphrenic and liver abscess may be prevented in certain cases if one is familiar with the variety of conditions which are responsible. Prompt recognition and proper management of these preceding intra-abdominal infections preclude the spread of infective material along any of the avenues which reach the liver or subphrenic space; when the complication does occur, the management is the same as in primary abscess.

Early recognition and timely operative intervention should be the aim of every surgeon and clinician, lest fatal secondary pathologic changes ensue.

Supportive measures should be instituted as early as possible. Transfusions are highly beneficial for patients with secondary anemia; large quantities of 5 per cent dextrose injected intravenously are especially indicated. When the patient is so poor an operative risk, such preoperative therapeutic measures often tide him over the shock incident to even so slight an operation.

The method of approaching the abscess cannot be governed by any rules, as each case is individual. The choice of approach should depend, as it did in my cases, on the location of the abscess as indicated by the signs and symptoms. I have chosen either the anterior or posterior route or the combined routes whenever it appeared that adequate drainage would be best secured. Contamination of the pleural and peritoneal cavities is the great danger one must guard against. When feasible, a two-stage operation is advisable to insure the formation of adhesions about the liver or subphrenic space, thereby excluding it from the pleural and peritoneal cavity. When this field is properly isolated, the abscess is opened and drained; thorough drainage is essential. This may not only be enhanced by the proper use of the aspirator at the time of operation, but may be repeated in bed. This procedure was carried out in case 4. Supportive treatment should be continued until the patient is well advanced toward recovery from this prolonged illness.

MORTALITY

The outcome depends on several factors: the extent and location of the abscess, its duration and the extent of secondary pathologic changes, which alone may be sufficient to terminate life. A pylephlebitis is invariably fatal; multiple liver abscesses and an undrained liver or subphrenic abscess are usually fatal. According to Lockwood,[6] in the cases in which operations are performed, the mortality rate varies between 20 and 50 per cent. In the primary type, it seems that the mortality rate is apt to be greater, because it is slightly more difficult to recognize. One of the three patients with a primary subphrenic abscess died without having been operated on. Three of the five patients with abscess of the liver died; two were operated on several times, but for secondary collections of pus apparently remote from the huge primary liver abscess which was undiscovered until after death; the third died of a diffuse peritonitis as a result of leakage of pus into the peritoneal cavity.

It is well known that spontaneous rupture of a subphrenic abscess may occur into almost any adjacent organ or space. In one, it perforated into the pleura, resulting in almost immediate death; another ruptured into a bronchus; in two, it was breaking through the chest wall and appeared in the lower part of the axilla as a fluctuating area. Spontaneous rupture may occur into any hollow organ, where spontaneous cure may result.

In one case reported here (case 7) and in another case of secondary subphrenic abscess following acute appendicitis, the pus gravitated to the perinephric region and gave the clinical signs of a perinephric abscess. Incision and drainage of the perinephric abscess did not result in a cure in the latter case until at a second operation a sinus tract was traced to the right subphrenic space, where a huge collection of pus was drained; rapid recovery then took place. The patient in my case 7 was not so fortunate.

COMMENT

Objection might be made to the terminology of primary liver or subphrenic abscess as applied to the eight cases reported in this paper. I have tried to avoid this designation, but because of the absence of any evidence of the usual causative factors I feel justified in this decision.

In case 1 the patient had a severe pyuria, the source of which could not be determined; the kidney corresponding to the side of the abscess showed no gross pathologic change. The association of the pyuria and subphrenic abscess is purely speculative. The patient in case 6 had an empyema thoracis, subphrenic and liver abscess. One might argue in

6. Lockwood, A. L.: Surg. Gynec. Obst. **33**:502, 1921.

favor of a diagnosis of primary empyema with the other lesions secondary; the facts favor the reverse.

The patient in case 4 gave a history of jaundice and pain in the right upper quadrant one year before, which lasted for only one week. This is strongly suggetive that some biliary infection was present which recurred at the present time leading to a liver abscess.

That some obscure undiscovered gastro-intestinal lesion was present cannot be affirmed. It is not unlikely that some form of infection, known commonly as grip, was present, but no causal relation could be established.

One might interpret the changes in the lung as real pneumonia and a primary source of the subphrenic lesion. I can say with almost absolute certainty that the lung is compressed by the elevated diaphragm and the plural fluid. The latter changes promptly disappear after the abscess is drained and the diaphragm returns to its normal position. If extension takes place from the lung to the subphrenic region, one would have to imagine a retrograde lymph flow.

CONCLUSIONS

1. Liver and subphrenic abscesses arise without demonstrable foci of infection, thus constituting the primary and idiopathic type.

2. The recognition of this condition is usually late, when it is well advanced.

3. The condition is most commonly mistaken for pneumonia or pleurisy with effusion.

4. The roentgenograms and fluoroscopy aid in disclosing the lesions.

5. The roentgen features are: (*a*) an elevation of the diaphragm with restricted excursion, (*b*) the presence of air with or without a fluid level beneath the diaphragm and (*c*) intrathoracic changes leading to a diagnosis of pneumonia and pleural effusion.

6. The mortality rate is high because the condition is either not recognized at all or is recognized so late that extensive associated pathologic changes have taken place or because the abscess is inadequately drained. In the patients in whom the cases were recognized early and who were operated on promptly, the mortality rate was greatly reduced.

REPORT OF CASES

CASE 1.—P. R., a man, aged 47, was first seen by me on May 3, 1928, because of mild pain in the suprapubic region of three days' duration and unassociated with other symptoms. Physical examination failed to reveal evidence of abdominal disease. There was a moderate number of pus cells in the urine; the prostate was not enlarged, and a marked phimosis was present. The following day there was slight difficulty in voiding; the number of pus cells in the urine had increased. Roentgen examination of the genito-urinary tract failed to reveal any evidence

of calculi. On the following day, a circumcision was done so that a cystoscope could later be introduced to study the urinary tract. The wound was healed in ten days. Frequency of urination, dysuria, pyuria and a rise in temperature continued for several days; there was no abdominal or kidney tenderness. Sore throat, generalized pain and chilly sensations developed; in other words, a condition that proved to be a grip infection. The patient looked septic, and was advised to enter the hospital on May 21. On admission, the temperature was 103 F., respirations 23 and pulse rate 100. In the right side of the chest posteriorly at the base, a few subcrepitant râles were heard, and later signs of lobar pneumonia developed. The abdomen was soft but not tender. No masses were felt. The blood showed: white blood cells, 12,000; polymorphonuclears, 76 per cent, and lymphocytes, 24 per cent. The urine had large amounts of pus clumps. A Widal test, chemical analysis of the blood and blood culture gave negative results. In ten days, the pneumonia of the right lower lobe had resolved almost completely, and the left lower lobe was involved; this was confirmed by the roentgen ray. Cough was slight, with little expectoration; the sputum did not show tubercle bacilli and was negative for types 1, 2 and 3 pneumococcus. The hemoglobin was reduced to 55 per cent; the white blood cells were now 18,400 with a high differential count.

The patient looked profoundly septic. A transfusion of 300 cc. of citrated blood was given in bed. Signs in the left side of the chest continued for about two weeks, at which time fluid was thought to be present in the pleural cavity. There was now pain in the left lumbar region, with marked left costovertebral tenderness. Roentgen examination of the chest showed an unresolved pneumonia with some fluid on the left side. On fluoroscopy, the diaphragm moved freely on both sides. The course was still septic; there were profound weakness and anemia; the hemoglobin was down to 42 per cent; sweating was profuse and constant, and emaciation was marked. Another transfusion of 450 cc. of whole blood was given. About six weeks after admission, a tap of the left side of the chest resulted in 30 cc. of clear straw-colored fluid which contained gram-positive cocci that failed to grow on culture; tubercle bacilli were not present. Blood culture was sterile. About two months after admission, there was slight bulging and edema over the lower part of the left side of the chest in the postaxillary part. This sign was persistent and seemed to favor a previous clinical impression that a subphrenic abscess existed and that the changes in the left side of the chest were secondary. Within the following week, 35 cc. more of clear straw-colored fluid was aspirated from the left side of the chest. Repeated roentgen examination and fluoroscopy showed unresolved pneumonia with pleuritis and moderate pleural effusion. Exploration of the left subphrenic space was considered mainly on the clinical features, but this procedure appeared somewhat too radical without the usual roentgenologic evidence which was familiar to me. About two days before the operation, the last roentgen examination and fluoroscopy revealed the left half of the diaphragm to be slightly more elevated and restricted in excursion. Another transfusion was given. Operation was undertaken on July 31, about ten weeks after the patient's admission to the hospital. An incision was made over the left kidney, because it appeared as if a perinephric abscess might be present which extended to the under surface of the diaphragm. The left kidney and perinephric space were found lacking in gross evidence of disease. When the hand was insinuated upward toward the diaphragm, a large mass was discovered which was obviously inflammatory. Pus was obtained after several punctures; the abscess was opened and drained. The pus yielded *Bacillus coli* on smear and culture. There was considerable postoperative shock for twenty-

four hours, but following that convalescence was uneventful. The patient was discharged twenty-four days after the operation. The drain had been removed a long time before and the wound was almost entirely healed. He is now well. It may be of interest to mention that the pathologic changes in the chest disappeared almost entirely a few days after the operation.

CASE 2.—A. S., a woman, aged 44, was admitted to the hospital in March, 1927, with pain in the left side of the chest and elevation in temperature. The present trouble began five weeks previously with sore throat, fever and malaise. She was told that she had grip and was advised to stay in bed for a few days; temporary improvement followed. Three weeks before admission the symptoms recurred, but were more aggravated. Pain was sticking in character and more marked on inspiration; there were chilly sensations, a slight cough and fever. Her previous history was unimportant except for pneumonia six years before, and diabetes was present for seven years.

On admission she looked acutely ill and slightly cyanotic. The lower part of the left side of the chest was sensitive to anteroposterior compression. There was also a small area of bronchovesicular breathing over the base of the left lung. with an increase in transmission of spoken and whispered voice. The abdomen was tender in the left subcostal region, and the muscles were spastic but not rigid; there was tenderness over the left kidney as elicited by first percussion.

The temperature ranged between 99 and 102 F. throughout the entire course. The white blood count was 16,800, with a differential count of 84 per cent polymorphonuclears and 12 per cent lymphocytes; the red blood count was 3,800,000. The urine showed a moderate number of white cells. More tenderness gradually developed in the left upper quadrant, also a mass which at first gave the impression that it was a kidney mass. The latter being excluded by cystoscopy and roentgen examination, a left subphrenic abscess was strongly considered. This mass grew larger and nearer to the ensiform, where it showed fluctuation. Roentgen examination five days after admission showed no gross changes in the lungs; the left half of the diaphragm was higher than normal. At a later examination, the stomach showed no evidence of an organic lesion.

Four weeks after admission a large left subphrenic abscess was drained through an incision over the fluctuating area. *Staphylococcus aureus* was cultured from the pus. The patient made an uneventful recovery and was discharged nine days later with a small sinus.

CASE 3.—A. R., a man, aged 35, was admitted to the hospital in April, 1926, with severe pain in the right side of the chest and fever. The onset of the present illness was four months before, when he noticed that he tired easily, had pains in the limbs and a slight rise in temperature varying between 100 and 102 F.; he was told that he had grip, so he rested for several days. Three weeks before admission, he developed pain in the right side of the chest which was aggravated on inspiration; the pain radiated to the right shoulder. One week before admission, the temperature began to run a septic course; he perspired freely and became very weak; there was no cough or bloody expectoration. A roentgenogram of the chest before admission failed to reveal any changes in the lungs.

On examination, although he seemed well developed, he had lost weight; he perspired profusely. The right side of the chest was dull at the base anteriorly and posteriorly; there was diminished breathing; no râles were present. The heart was pushed slightly to the left. The abdomen was soft, not tender; there was some pain on anteroposterior compression of the lower right side of the chest.

The temperature was 104 F.; the pulse rate was very rapid, and respiration at times was rapid. The blood showed 20,000 white cells, with a differential count of 82 per cent polymorphonuclears and 18 per cent lymphocytes. The condition was regarded as pleurisy with effusion. On aspiration, 260 cc. of clear serous straw-colored fluid was obtained from the right side of the chest which showed no organisms on smear or culture and no tubercle bacilli. Bronchial breathing was heard after the chest was tapped. Slight tenderness developed in the right upper quadrant. A few days later, the chest was tapped again and 15 cc. of similar fluid was obtained.

Five days after admission, roentgen examination revealed the right half of the diaphragm to be higher than normal. Fluoroscopy showed diminished excursion; there was also a small air pocket below the diaphragm. The roentgenologist's opinion was that there was a lesion below the right half of the diaphragm, probably an abscess.

Two weeks after admission, a roentgenogram confirmed the previous report and revealed a dense homogeneous shadow in the right basal region, which was interpreted as pleural effusion.

The clinical course was distinctly septic; the patient was progressively getting worse; weakness was extreme, and profuse perspiration was constant. He suddenly went into collapse; his pulse became very rapid, almost imperceptible; there was marked cyanosis; râles were heard over the entire chest. Death followed. Immediately after death, aspiration of the chest revealed seropurulent fluid.

The subphrenic space was also punctured, and 250 cc. of purulent exudate was obtained. Autopsy was refused. It appears likely that the subphrenic abscess perforated into the right pleural cavity causing almost sudden death. At this time, the pleural fluid did not show any organism on smear or culture. Guinea-pig inoculation failed to show evidence of tuberculosis. Through some error, the subphrenic exudate was not examined bacteriologically.

CASE 4.—C. L., a man, aged 40, was admitted to the hospital in February, 1929. Three weeks before, he suddenly experienced a sharp, sticking pain in the right upper quadrant. He had some fever and a slight cough. His condition was thought to be influenza, so he was advised to stay in bed for one week, after which he improved. He left the city for two weeks, but when he returned the rise in temperature and cough returned. Jaundice had also developed. His past history was unimportant, except that he believed that he had had a similar condition about one and one-half years before, which lasted for only one week, after which he had felt well until the present time.

On entrance to the hospital, he looked acutely ill and was moderately jaundiced. There were fine crackling râles at the right base posteriorly; breath sounds were diminished; the left side showed no change. The abdomen revealed a large liver reaching five fingerbreadths below the costal margin; marked tenderness was present in the right upper quadrant and also in the right costovertebral angle. The urine did not show any change. The temperature was 104 F.; respiration, 25, and the white blood count 16,800, with a differential count of 88 per cent polymorphonuclears and 12 per cent lymphocytes. On admission a diagnosis of pneumonia was made first; then a provisional diagnosis of subphrenic or liver abscess was promptly made, and was confirmed by the roentgen ray and fluoroscopy.

The roentgen examination disclosed infiltration at the right base; the right half of the diaphragm was slightly higher than normal; below the diaphragm was seen air with a fluid level; diaphragmatic excursion was slightly restricted. The

conclusion was that an abscess of the liver was present, although a subphrenic abscess could not be excluded.

Immediate exploration through an incision in the right upper quadrant disclosed a large abscess in the liver when it was punctured. The needle was left in situ, and the liver was packed all around to wall it off from the peritoneal cavity; forty-eight hours later, the abscess was opened and drained; 1,500 cc. of pus was obtained by suction. For three days following the operation the patient's course was septic, but thereafter he made an uneventful recovery and was discharged thirty-five days later.

CASE 5.—A. B., a man, aged 30, was admitted to the hospital in December, 1927, complaining of sore throat, pain in the chest and back and chilly sensations and fever, all of which began six days before. A physician diagnosed his condition as grip. After a short rest in bed, he improved. Shortly after he experienced a tired feeling, pain in the chest and chilly sensations; he perspired freely. It was believed that pneumonia was developing. When he entered the hospital, he looked acutely sick. Over the right side of the chest posteriorly there was diminished tactile and vocal fremitus. There was flatness to percussion at the right base, and no râles; breath sounds were distant and bronchovesicular. The abdomen was soft, not tender or rigid in any part.

The diagnosis was pleurisy with effusion.

The temperature was 102 F., respiration, 22, and pulse rate, 100; the urine showed a trace of albumin, a few granular casts and a moderate number of white blood cells; the blood count was 14,000, with a differential count of 85 per cent polymorphonuclears and 15 per cent lymphocytes. The patient's course continued septic. The blood culture was sterile. A roentgenogram of the chest five days after admission failed to reveal any gross changes in the lungs. Twelve days after admission, 50 cc. of clear, straw-colored fluid was aspirated from the right side of the chest; no organism was obtained on culture of this fluid. Of the cells present, 95 per cent were polymorphonuclears and 5 per cent lymphocytes.

Another roentgenogram taken seventeen days after admission showed a homogeneous shadow in the right side of the chest from the sixth rib down, merging with a slightly elevated diaphragm. The diaphragm moved freely. The roentgen observations suggested a lesion below the diaphragm, probably in the liver, because of free excursions of the diaphragm.

The following day the ninth rib in the postaxillary region was resected, the pleura was pushed away from the diaphragm and a liver abscess was opened and drained; the pus contained nonhemolytic streptococci. The following day the abdomen was markedly distended and tender, more markedly in the lower quadrant. The abdomen was opened, because an intraperitoneal infection was suspected; no exudate was found. The old abscess was explored through the old incision, and then an incision parallel to the right costal margin was made. A large quantity of pus was evacuated. The patient's condition was desperate; the pulse was very weak and rapid; the temperature was 106 F.; death ensued the following day.

At autopsy, a large multilocular abscess was found in the right lobe of the liver; this had perforated into the subphrenic space and then through the diaphragm to form a localized collection of pus under the right lobe of the lung. The right lung was compressed at the base. Both lungs contained many small abscesses. There was a diffuse peritonitis due to leakage of pus from the liver abscess along the right lumbar gutter, where most of the exudate was found.

CASE 6.—K. B., a man, aged 47, was admitted in September, 1926, complaining of pain in the right side of the chest and fever, which had developed thirteen days

before after exposure to rain. He was compelled to remain in bed for a few days on account of marked weakness and chills.

On admission, he looked acutely ill. The temperature was 101 F., and respiration, 35. Over the right base posteriorly there were flatness, diminished tactile fremitus and distant tubular breathing. In the right upper abdominal quadrant, tenderness and slight resistance were present; the white count was 13,000, with 88 per cent polymorphonuclears and 12 per cent lymphocytes. A tentative diagnosis of pneumonia with pleural effusion was made. The chest was tapped, and purulent exudate was obtained at the eighth interspace. The following day, part of the eighth rib was resected for what appeared to be empyema; some purulent exudate was obtained. The patient's course remained septic with the temperature ranging between 101 and 103 F., sometimes higher. The pus from the empyema showed gram-positive cocci on smear, but no growth on culture. It was negative for pneumococcus types 1, 2 and 3. A chemical analysis of the blood and urinalysis gave negative results.

Two weeks after admission, a roentgenogram of the chest disclosed the right half of the diaphragm higher than normal, and the fluoroscope showed diminished excursion; these observations suggested a lesion below the diaphragm. In the right upper quadrant, a tender, bulging mass developed which was thought to be an abscess of the liver. On September 22, an abscess of the liver was drained through a right upper rectus incision. Three weeks later, a subphrenic abscess was drained through the old incision. The pus from the abscess of the liver was sterile. *Staphylococcus aureus* was obtained from the subphrenic abscess. The patient made an uneventful recovery after the last operation, and was discharged on November 9.

It seems more likely that a primary abscess of the liver was at first present, which perforated into the subphrenic space and then subsequently infected the pleural effusion, causing empyema.

Case 7.—H. K., a woman, aged 27, came to the hospital on July 7, 1924, with pain in the right costal margin and fever. She had pneumonia three months before and remained in bed for ten weeks. Since then she had pain in the right side of the chest posteriorly and in the right costal margin; it had been much worse for the past five weeks; she had lost weight and had become considerably weakened.

When she entered the hospital, she appeared pale and had a few fine râles at the right base posteriorly. There was tenderness of the right costal margin and the lower part of the right side of the chest posteriorly, which was best elicited by anteroposterior compression of the right side of the chest.

The temperature was 102 F., the pulse rate 90, and respiration, 20; hemoglobin was 66 per cent, and the white blood count was 16,200. The urine was normal. The chemical analysis of the blood gave negative results. A few days after admission, there was tenderness in the right loin and costovertebral angle. A perinephric abscess was suspected. Cystoscopy and roentgenography failed to reveal any evidence of pathologic changes in the genito-urinary tract.

Two weeks after admission, an area of induration and fluctuation, 3 inches (7.6 cm.) in diameter developed, which was apparently adherent to the tenth to the twelfth ribs in the right axillary region; a puncture in this area failed to reveal pus. A roentgenogram of the chest at this time showed a few fine infiltrations in the right base from the seventh rib to the diaphragm; there were no gross changes in the left lung. The right half of the diaphragm was limited in excursion.

An incision over this indurated area over the right side of the chest revealed the presence of pus, probably an abscess of the chest wall. The pus showed no

organisms on smear or culture. The discharge gradually diminished, and a small sinus remained. Five weeks later, induration developed about the sinus, so further exploration was done; the tenth rib was resected for about 2 inches (5 cm.). A small amount of purulent exudate was again drained. Healing had again resulted in a persistent fistula. The pus was sterile, no tubercle bacilli were found and no evidence of actinomycosis. The patient was discharged on Nov. 12, 1924, with a sinus in the lower right side of the chest region which was persistent. She returned on Jan. 12, 1925, when the sinus was again explored and found leading downward anteriorly to the pleura, where a small collection of purulent exudate was discovered. *Staphylococcus aureus* was now present in the pus. There was no evidence of malignancy. The Wassermann reaction was negative. Roentgen examination of the chest showed partial obliteration of the right costophrenic sinus with a few fine infiltrations in the right lung. The ribs did not show evidence of osteomyelitis.

The wound again healed, but a persistent fistula remained. The patient was discharged on March 6.

She was readmitted on June 2. She continued to lose weight, and was becoming more anemic, emaciated and weakened; the temperature was low grade. Exploration of the sinus at the time traced it down to a large perinephric abscess which contained several ounces of pus. There was still limitation of the right half of the diaphragm. The source of the trouble was finally thought to be located. The wound healed in a few weeks, but again a sinus tract which was discharging seropurulent exudate remained. She was discharged on August 9, and readmitted two weeks later. On her last admission, a roentgenogram still showed limitation in excursion of the right half of the diaphragm with infiltration in the right base. Guinea-pig inoculation of the sputum failed to produce tuberculosis. She continued down hill, and her septic appearance became progressively worse. Blood culture was sterile. The sinus continued to discharge.

One morning, November 10, while sitting up in bed she suddenly went into collapse and died, about seventeen months after her first admission.

On postmortem examination, a huge abscess of the liver was found in the right lobe, which had perforated into the subphrenic space. The liver was firmly bound to the wall of the chest by cartilaginous-like adhesions. The diaphragm was also adherent to the liver. The abscess appeared very old, as its wall was unusually thick and cut like cartilage. The right lung showed a considerable degree of fibrosis with dilatation of the bronchioles and bronchi. There were several small abscesses in both lungs.

The abscess was undoubtedly primary and was completely overlooked. The perinephric collection of pus was a secondary gravitation abscess. The only suggestive evidence of the existence of this lesion was a persistent elevation and limitation of the right half of the diaphragm. I failed to appreciate the significance of this sign because of my lack of experience in cases of this type.

CASE 8.—L. H., a man, aged 29, came to the hospital on Jan. 24, 1923, complaining of pain in the right side of the chest, cough and fever. He became ill six weeks before, when his physician advised him to stay in bed for several days, believing that he had the grip. As he did not improve, he was taken to another hospital, where he remained for two weeks. A roentgen examination of the chest then revealed no gross changes. For the past two weeks, he had had severe pain in the right side of the chest, and on the day of admission he discovered a tender area over the right side of the chest. He had had chilly sensations and was considerably weakened since the illness.

Examination revealed the patient to be markedly emaciated, anemic and septic. The right side of the chest was almost flat to percussion up to the angle of the scapula; breath sounds were markedly diminished; subcrepitant râles were present. At the lower postaxillary region of the right side of the chest, there was a large fluctuating area which did not pulsate. The first impression was that an empyema necessitatis existed.

The temperature varied usually between 100 and 103 F. with elevation to 105 F.; respiration was 25; the white cell count was 28,800 with a differential count of 94 per cent polymorphonuclears and 6 per cent lymphocytes. A roentgenogram of the chest disclosed partial obliteration of the right costophrenic sinus with the presence of fluid; the right half of the diaphragm was higher than normal, suggesting at that time a lesion below the diaphragm which was also slightly limited in excursion. An incision over this fluctuating area disclosed a large abscess cavity leading in a downward direction and apparently extrapleural. The pus emitted a foul odor resembling that of a colon bacillus infection. A culture of the pus revealed a nonhemolytic streptococcus. The course of the illness continued septic; he had repeated chills, perspired profusely and showed a marked weakness, with wide variations in temperature.

A roentgenogram taken eighteen days after this operation still showed a high diaphragm, but less high than before.

A second operation was done four weeks after the first in order to secure better drainage. A portion of the tenth rib was removed. This did not improve the condition.

On Feb. 25, 1923, he suddenly complained of severe pain in the right side of the chest, a choking sensation and difficulty in breathing; he coughed incessantly and raised large quantities of foul-smelling pus.

An abscess had apparently perforated into a bronchus. He improved slightly, although he continued a septic course with severe chills; blood cultures were sterile. His condition became progressively worse until his death, which occurred two months after his admission.

Autopsy revealed a huge abscess in the right lobe of the liver which had perforated into the subphrenic space. The right lung showed marked fibroses and was intimately associated with the diaphragm. The bronchioles and bronchi were moderately dilated. A communication between a bronchus and the abscess in the liver could not definitely be demonstrated, although there were sufficient suggestive evidence that such perforation had occurred at some previous time. The entire pleural cavity was obliterated by dense adhesions. There were a few small abscesses in both lungs.

THE CAUSE OF DEATH FOLLOWING RAPIDLY THE TOTAL LOSS OF PANCREATIC JUICE*

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In a previous paper,[1] the fatal effect of continued loss of the entire external secretion of the pancreas after intubation of the main pancreatic duct was described. Death occurred in from five to eight days. At that time the cause of death remained unexplained. A few studies of the blood showed dehydration and reduction in the chloride concentration, and, unexpectedly, an increased alkalinity in the serum, an observation difficult to explain on the basis of extensive loss of such an alkaline secretion as the pancreatic juice. Further examination of the evidence, however, revealed the fact that these observations on the blood were made in dogs that had vomited considerably, a symptom of the gastric irritability almost always present to more or less severe degree in animals thus deprived of pancreatic juice. Vomiting, it was soon noted, was apt to be severe in animals that drank copiously, or in those given fluid by gavage. When they did not drink, or when water was withheld, vomiting was practically absent. The observation of the increased alkalinity of the blood in these early experiments was not deemed a sufficient cause for death. As the return of the secretion to the duodenum rapidly restored an animal to health it was supposed that the juice might contain some substance necessary for life.

A decisive answer to these questions has been made possible by a recent study of such intubated animals, care being taken to prevent loss of gastric contents by vomiting. Full details of these experiments have been reported elsewhere.[2] It was found, briefly, that when total loss of pancreatic juice occurred under sterile conditions and in the absence of vomiting the blood shortly before death showed extreme concentration with marked reduction in base bicarbonate and p_H, i. e., uncompensated acidosis. Such observations are what one might expect from a consideration of the alkaline composition of pancreatic juice.[2] When severe vomiting occurred in addition, the acidosis was less marked,

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1. Elman, R., and McCaughan, J. M.: J. Exper. Med. **45**:561, 1927.
2. Hartmann, A. F., and Elman, R.: J. Exper. Med. **50**:387, 1929.

absent or even replaced by alkalosis due to the superimposed loss of acid gastric juice, thus explaining the early observations.

PROTOCOLS

The following protocol describes the observations in a typical experiment:

PROTOCOL 1.—Dog 20 was operated on on Dec. 19, 1928, and a cannula was placed in the main pancreatic duct to collect the entire secretion of the pancreas as described before.[1] Blood was obtained before operation for chemical analysis. The first day 260 cc. of sterile pancreatic juice was obtained. The amounts secreted in the succeeding twenty-four hour periods were as follows: 400, 205, 320, 365, 440, 320 and 145 cc. Each specimen was clear, odorless and sterile as determined by cultures on blood agar as well as by examination of the sediment from centrifugated samples. Death occurred on the eighth day after operation with evidences of marked dehydration, asthenia and gastric irritability. The vomiting, however, was miminal and the amount of fluid actually lost in this manner did not exceed 200 cc. No treatment was given. Blood was obtained thirty hours

Changes in the Blood Serum in Dog 20

	Before Operation	After Six Days of Drainage
Carbon dioxide content, per cent by volume	55.0	23.5
Sodium chloride, milligrams per 100 cc.	600	473
Nonprotein nitrogen, milligrams per 100 cc.	30	147
Lactic acid, milligrams per 100 cc.	18.0	26.5
Total base, milligrams per 100 cc.	152	117
Protein, per cent	7.0	9.34
p_H	7.40	7.33

before death, that is, on the sixth day of drainage. The changes, as shown in the accompanying table, were those of uncompensated acidosis.

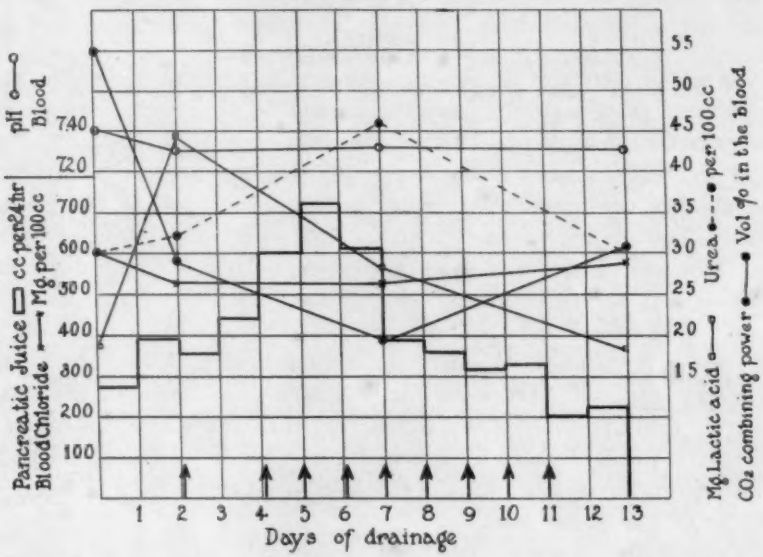
At autopsy, which was performed a few minutes after death, the peritoneum was clear and no infection was noted in the pancreas or collecting system. The heart was firmly contracted, the liver was engorged with blood and the blood was so concentrated that it did not flow from the cut aorta or vena cava. The stomach was small and contracted; the intestines were empty.

It should be emphasized that the method used in these experiments permitted the collection of the entire twenty-four hours' secretion of the pancreas under sterile conditions in a closed system. Gamble and McIver[3] recently reported similar observations in two dogs with open pancreatic fistula. Their animals lived for several weeks in contrast to the rapid death in our experiments. In large measure the difference is probably due to the difference in the amount of secretion lost to the body. In dogs draining pancreatic juice through an open wound, the inevitable licking of the fistula restores some of the secretion and the inflammatory changes in the pancreas always present in such cases

3. Gamble, J. L., and McIver, M. A.: J. Exper. Med. **48**:849, 1928.

often cause a marked diminution in the amount of juice secreted. These circumstances probably account for the longer life in their dogs.

Additional proof that this rapidly fatal outcome was due to simple chemical changes was the fact that death could be prevented and life prolonged during drainage of the pancreatic juice by the administration of sufficient Ringer's solution. When given intraperitoneally or intravenously the response was often marked. The animal became brighter and more active even though continuing to lose large amounts of pancreatic juice. A few dogs have been kept alive with daily injections of 500 cc. of solution for weeks and then were killed only because of accidental infection of the pancreatic juice. Though in good general



Observations on dog 23. Each arrow indicates the intraperitoneal administration of 500 cc. of Ringer's solution. The animal was killed on the thirteenth day of drainage because of accidental infection of the pancreatic juice.

condition there was always a marked loss of weight. Water alone, or with added dextrose, had no beneficial effects. The following protocol describes one such experiment.

PROTOCOL 2.—Dog 23 was intubated, as already described, on Dec. 29, 1928. The main observations are represented in the accompanying chart. After two days of drainage, the blood had already begun to show the changes mentioned. Ringer's solution was then administered intraperitoneally, 500 cc. each day, with marked improvement in the condition of the blood. Special attention was paid to the development of vomiting, which was slight, although the animal showed the usual signs of gastric irritability. Food and water were taken slowly and in small amounts. On two occasions 300 cc. of milk was given by gavage. Within a few minutes retching began and soon the entire amount was vomited.

On the thirteenth day of drainage, the dog was killed with chloroform because of accidental infection of the pancreatic juice. As a result the secretion was reduced somewhat in amount, became turbid and was foul in odor. Culture showed *B. coli*. The general condition of the animal remained good. The weight was 8 Kg., a loss of 4 Kg. from its preoperative level. At autopsy, the intestines were empty. There was no infection of the peritoneum, and the incision was healed. The stomach was small and contracted. When the duodenum was opened, three deep ulcers were found just distal to the pylorus. The largest one was about 1 cm. in diameter and was covered with a dark blood clot which was easily removed revealing a fairly deep base, down to the muscularis.

It is to be noted that the base bicarbonate did not return to the normal level. In more recent experiments a more effective solution containing sodium lactate was used.[2] The results following its use were much more striking, and the return of the blood to normal was more complete.

COMMENT

It would seem that death should be prevented or postponed by some mechanism that would diminish the amount of pancreatic juice secreted or lower its concentration of inorganic salts since it is the loss of these salts and water that is really responsible for the fatal result. Yet, in the absence of infection or obstruction, neither of these things take place. The amount secreted remains high even in the absence of any food stimulus,[1] and its base and bicarbonate content stays up to the end, as shown in our experiments [2] by the daily analysis of the pancreatic juice. The pancreas, it would seem, secretes a juice of more or less constant composition even when its constituents in the blood are reduced to a very low level. The same fact has been established for the gastric juice by Lim and Ni.[4] They found that the chloride concentration of the gastric juice, obtained by repeated histamine or psychic stimulations, remained high even when the chloride content of the blood was depressed thereby to a very low level.

Probable reasons why dogs intubated in this way for the collection of total pancreatic juice cannot tolerate food or water by mouth as normally have been mentioned before.[1] From a variety of evidence it was supposed that the removal of the alkalinizing pancreatic secretion [5] prevented neutralization of the gastric contents which, therefore, remained highly acid, could not be tolerated by the duodenum and were vomited. The present observations add support to this supposition. The gastric irritability of dog 23, already described, was marked at all times even though the general condition was good and the composition of the blood was approximately normal. The ulceration noted was found in three dogs, all kept alive for two weeks or longer by means of injections of physiologic solution of sodium chloride. This lesion of

4. Lim, R. K. S., and Ni, T. G.: Am. J. Physiol. **75**:475, 1925.

5. Elman, Robert: Probable Influence of Pancreatic Juice in the Regulation of Gastric Acidity, Arch. Surg. **16**:1256 (June) 1928.

itself could explain the gastric irritability and vomiting. Of wider interest, however, is the fact that this observation adds support to the theory that high gastric acidity is a factor in the causation of duodenal ulcer. Further observations will be reported later.

Clinically, these observations emphasize the importance of the pancreatic juice in cases involving loss of gastro-intestinal secretions. Such a loss occurs in a variety of conditions, such as prolonged bilious vomiting, intestinal fistulas or obstruction below the pancreatic duct and protracted diarrhea. Loss of pancreatic juice, if sufficient and continued, can of itself bring about a fatal outcome and explains the observation of acidosis in some cases. Loss of gastric juice, of course, also takes place in most cases and indeed is usually the more prominent factor, thus explaining the alkalosis. In either case, however, a marked dehydration occurs, which is probably the most important factor involved. The simple chemical solution containing sodium lactate [2] has actually been used in many such clinical cases with striking results. These will be reported later.

SUMMARY

From the observations herein reported, the cause of death following total loss of sterile pancreatic juice seems definite and simple. A profound dehydration results with marked loss of base bicarbonate and resulting uncompensated acidosis. The acidosis may be less marked or may even give way to a slight alkalosis if severe vomiting takes place with the superimposed loss of acid gastric juice. In either case, however, the dehydration with resulting changes in circulation is probably the main factor in the rapid death. That the fatal outcome is due to such simple chemical changes is also shown by the recovery and prolongation of life during drainage of pancreatic juice by the administration of a simple physiologic solution of sodium, potassium and calcium chloride. The clinical application of these observations has been briefly discussed.

FORTIETH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY

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(Concluded from p. 172)

MISCELLANEOUS

Injuries of the Hand.—Bunnell [32] pointed out the common errors which should be avoided in the treatment for injuries of the hand. Incisions should be well chosen and of adequate size. They should not sever the tendon pulleys in the fingers nor cut the nerves in the fingers or palms, especially the motor thenar nerve. The most pernicious incision and unfortunately the one usually made was the median longitudinal one, whether in the palm, wrist, finger, pulp, matrix or dorsum of the finger. It wrecked the hand, caused flexion contractures by being at right angles to the flexion creases, cut the pulleys, caused adhesions at the worst place, namely, the gliding surfaces of the tendons, and was poor for drainage. In the fingers the incisions should be midlateral and not anterolateral where they will cut the nerves; in the hand they should follow as much as possible the natural creases. Drains ought not to be left in longer than two days, and large hot compresses of boric solution with 0.5 per cent sodium citrate should be used together with local and bodily rest. Traumatized wounds should not be sutured without debridement. When an incision is made in the

32. Bunnell, S.: California & West. Med. **30**:1 (Jan.) 1929.

hand, a tourniquet should always be used. Tendons should not be sutured more than twenty-four hours after an injury, as infection is almost inevitable. The exact type of infection present should always be diagnosed before one proceeds with the treatment. Infections of the tendon sheaths or palmar spaces ought never to be treated in an office. Local anesthetics should be avoided unless of the nerve block type. The wrist, hand and fingers ought to be kept in the position of optimum function during healing.

[ED. NOTE.—Bunnell has had extensive experience with injuries and infections of the hand, and we feel that his advice should be heeded. The article deserves the careful study of surgeons handling this class of work.]

Dupuytren's Contraction.—Kanavel, Koch and Mason [33] reported the results of their studies of Dupuytren's contraction together with the twenty-nine cases on which it was based. Seven of the patients had been operated on previously, some of them more than once, in spite of which the condition had recurred. The results observed in such patients and the results obtained in the patients operated on by the authors impressed them with the importance of the following: 1. Wide excision, not only of the contracted fascia, but of all its attachments to the skin, the interfascial septums, the volar interosseous fascia, the metacarpal bones and the phalanges. In case of doubt they preferred to err on the side of removing apparently normal fascia, and they considered this an added guarantee against recurrence. 2. Careful dissection and elevation of the skin to avoid trauma and subsequent necrosis. 3. Painstaking effort to avoid injury or division of the digital nerves and blood vessels which were frequently embedded in the bands of fibrous tissue which draw the fingers into flexion. 4. Excision of skin that is hopelessly involved and replacement of the excised skin by a free full thickness graft rather than an attempt to bring together the edges of the wound under tension. 5. In long-standing cases with marked contraction of the fingers, excision of the head of the proximal phalanx and shortening of the extensor tendon of the affected fingers through a dorsal incision (Hutchinson's operation). 6. Active movement of the fingers and hand as soon as the operative wound is soundly healed.

The authors were of the opinion that if treated in such a manner complete restoration of function might reasonably be hoped for, although cellular infiltration of the hand and partial anesthesia and stiffness of the fingers were to be expected for a considerable time after the operation.

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33. Kanavel, A. B.: Koch, S. L., and Mason, M. L.: Surg. Gynec. Obst. **48**: 145 (Feb.) 1929.

Pathologic Dislocations of the Femur.—LeFort [34] made a study of simple pathologic dislocation of the hip, meaning by this a dislocation that had occurred as the result of disease but without modification in the shape of the bones sufficient of itself to bring about the dislocation. He found that in tuberculous coxitis, dislocation occurred sometimes suddenly in the early course of the disease but more often gradually at a later period. In acute osteomyelitis, dislocation resulted sometimes from a direct suppurative involvement of the joint, more frequently it was the consequence of a para-articular lesion. It also occurred in the course of rheumatic disease and during convalescence from acute general diseases, especially septicemia and pyemia.

Multiple factors contributed to prepare the way for and to bring about the dislocation. The chief factors were: prolonged vicious attitude of the limb; softening of the cotyloid ligament; swelling and effusion in the joint; atrophy of the muscles, particularly of the gluteus maximus; contracture of the antagonistic muscles, and the effects of trauma, often of minimal character. Simple dislocation could not occur unless there was a relaxation of the capsule and ligaments and could not be complete unless the ligamentum teres was destroyed. As a general rule, the dislocation was only an accident in the course of a destructive arthritis and whether or not this was reduced, the usual destructive changes occurred later. When the dislocation was not reduced, however, bony changes developed due to the adaptation to the new position, and at a later period it was often difficult to recognize from the appearance of the hip that it had been a pathologic dislocation.

The treatment for a recent dislocation should take into consideration the treatment for the primary disease process first, but at the same time efforts should be made to reduce the dislocation either by traction and manipulation or by open operation. When reduced measures had to be adopted to prevent redislocation, even when reduction had been accomplished, the final result was modified by the evolution of the disease process and normal function was scarcely ever to be expected, but rather ankylosis or marked destruction of the articular surfaces, the functional effects of which were to be reduced to their minimum by proper therapeutic measures. The treatment for a long-standing pathologic dislocation was essentially the same as that of any long-standing dislocation whether congenital or traumatic.

Gill [35] wrote on the treatment for pathologic dislocation, basing his conclusions on the study of forty-four patients, in all of whom operation was performed. The dislocations were due to tuberculosis, pyogenic and pneumococcus infections, infantile paralysis and encephalitis. Sur-

34. LeFort, R.: Rev. d'orthop. **15**:514 (Nov.) 1928.

35. Gill, A. B.: South. M. J. **22**:207 (March) 1929.

gical intervention was indicated to secure stability of the hip, relieve pain, correct deformity and to obtain motion if this was consistent with stability and freedom from pain. The author advised against osteotomy of the femur, since in his experience it did not correct the deformity and left either a painful fibrous ankylosis or a great instability. The author preferred to perform either the reconstruction operation or an arthrodesis, the choice depending on a careful appraisal of all the circumstances of the case.

Bilateral Snapping Hip.—Dickinson [36] considered true snapping hip to be a relatively unusual condition, and stated that bilateral snapping hip was rare. The usual cause was a thickening of either the iliotibial band or the tendon of the gluteus maximus. He said that operations for relief from the condition ought to be performed with the aid of local anesthesia, as it was essential to see which band was at fault; the snap usually disappeared under the relaxation of general anesthesia. He considered early mobilization of the hip following the operation essential.

Fat in Traumatic Effusions of the Knee Joint.—By the use of special methods, Kling [37] was able to demonstrate the presence of a considerable quantity of fat in the synovial fluid of six patients with traumatic hemorrhagic effusions of the knee joint. The interjoint fat deposit and the bone-marrow of the epiphysis were considered to be the source of the fat, hence the presence of fat indicated an injury to the interjoint structures (crucial ligaments and semilunar cartilages) alone or combined with fracture of the articular surfaces. The presence of the fat was demonstrated by centrifugalization of the aspirated fluid, which caused it to separate in an easily recognizable layer.

Eburnation of the Tibia.—Froelich [38] observed four patients with eburnation of the tibia and reviewed similar cases that have been reported in the medical literature. His patients were girls ranging in age from 6 to 12 years. The lesion manifested itself clinically by pain, or in some instances only by tenderness to pressure and by an increase in the volume of the bone. Roentgen examination showed a zone of bone condensation at the level of the middle third of the tibia and a decrease in the size of or a total disappearance of the medullary cavity. According to various authors, this disease might appear in the first weeks of life. The bone was opaque on roentgen examination, broke easily and might fracture spontaneously. Putti gave the condition the name eburnating osteitis; Albert-Schoenberg, marble bone, and Leri, hyperostosis.

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36. Dickinson, A. M.: Am. J. Surg. **6**:97 (Jan.) 1929.
37. Kling, D. H.: Am. J. Surg. **6**:71 (Jan.) 1929.
38. Froelich: Rev. d'orthop. **16**:1 (Jan.) 1929.

Major Frequency of Orthopedic Diseases on the Left Side.—From Spitzy's large clinic comprising more than 7,000 cases, Aberle-Horstenegg [39] compiled statistics which showed that diseases of an orthopedic nature involved the male sex and the left side of the body with much greater frequency than the female sex and the right side. This was particularly noted in respect to the hip joint, including such lesions as tuberculosis, congenital dislocation, Perthes' disease and morbus coxae senilis.

Massage as a Therapeutic Agent.—Massage, according to Jarman,[40] exerted its therapeutic action in two ways: mechanical action and reflex action. Mechanically, it stimulated the circulation of blood and lymph, and acted on tissues and organs by tension and pressure. There was no direct proof of its reflex action, but contraction and relaxation of musculature were observed during massage. Massage produced changes in muscular tissue without producing fatigue. Experiments so far indicated that massage was not accompanied by lactic acid and carbon dioxide formation. Massage should never be used in acute inflammatory conditions. It should be carried out only by trained persons at the order of physicians familiar with the patient's local and general condition.

[ED. NOTE.—Much remains to be learned of the action of massage. All observers agree that the effect is not wholly to be explained on the basis of mechanical action. Now that progress is being made in the understanding of physiology of the muscle, it is to be hoped that additional facts will be forthcoming to give one a more rational basis for its use. We believe that Jarman's recommendations are sound.]

Longitudinal Osteotomy.—In discussing methods of performing osteotomy, Haas [41] stated that the chief desideratum was correction of the deformity with a minimum displacement of the fragments. He described a method that he had found useful, in which he performed a series of longitudinal osteotomies through the entire thickness of the cortex, each about from 3 to 4 cm. long and about 1 cm. apart. This weakened the bone sufficiently to allow it to yield to a bending force applied in any direction. Rotary deformities could also be corrected without disturbing the continuity of the bone. The time required for healing was less than with the usual transverse osteotomy.

Operative Substitution of the Thumb.—Joyce [42] recorded the present condition of two patients on whom he had substituted a ring finger of the opposite hand for a thumb.

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39. Aberl-Horstenegg, W.: Ztschr. f. orthop. Chir. **51**:489, 1929.
40. Jarman, M. B.: Virginia M. Monthly **55**:731 (Jan.) 1929.
41. Haas, S. L.: Longitudinal Osteotomy, J. A. M. A. **92**:1656 (May 18) 1929.
42. Joyce, J. L.: Brit. J. Surg. **16**:362 (Jan.) 1929.

In the first patient operated on twelve years ago, the excellent immediate result was marred later by flexion deformity at the new metacarpophalangeal and interphalangeal joints, and these joints were subsequently ankylosed. Since this ankylosing operation, done seven years ago, the man has worked as an upholsterer, and the new thumb feels to the patient as "if it were his old thumb."

The second patient, operated on nine years ago, has developed a similar flexion deformity at the new metacarpophalangeal joint. The new digit is stable and allows half the extent of passive movement possible in the carpometacarpal joint of a normal thumb; the metacarpophalangeal joint of the new thumb (proximal interphalangeal joint of the old finger) has a flexion deformity of 90 degrees, and only a few degrees of passive movement. The interphalangeal joint of the new thumb (distal interphalangeal joint of the old finger) is not deformed and allows a few degrees of passive movement. Joyce said that the aim of the operation—the provision of a fixed sensitive thumb to which the patient could oppose the remaining fingers of the hand—had not been realized in this case, partly owing to the flexion contracture at the metacarpophalangeal joint and partly to an initial error in technic, whereby the finger was transplanted with its transverse plane nearly parallel to that of the palm of his hand instead of at right angles to it.

Transplantation of the Thumb Nail.—Sheehan [43] succeeded in transferring a part of the nail from one thumb to the other thumb in a boy aged 16, who had had absence of growth of the thumb nail for two years following an injury. The result was excellent in both thumbs. He pointed out that the nail was epithelial in origin, like the epidermis, and that success was usually to be expected with such tissues. There were several technical difficulties in both the operation and the after care, but it was possible to overcome these by attention to small details.

Trisacral Fusion.—A new operative technic for the combined fusion of both sacro-iliac joints and of the lumbosacral joint at one sitting was described by Chandler.[44] Exposure of all three joints was obtained by a curved incision with convexity upward passing in the transverse plane across the posterior surface of the sacrum. A modification of Hibbs' method of fusion was employed to ankylose the fifth lumbar vertebra to the sacrum while the method adopted for stabilizing the sacro-iliac joints resembled that described by Gaenslen. The operation had been performed in five patients, and the author considered that the immediate results were of such a nature as to warrant the more extensive trial of the procedure.

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43. Sheehan, J. E.: Replacement of Thumb Nail, J. A. M. A. **92**:1253 (April 13) 1929.

44. Chandler, F. A.: Surg. Gynec. Obst. **48**:501 (April) 1929.

The reason for developing the operation of trisacral fusion was the necessity of relieving patients with pain low down in the back and sciatic pain in whom it was impossible to determine whether the pathologic cause was situated in the sacro-iliac or the lumbosacral joints, also the fact that in certain patients not one but two or all three of the sacral joints participated in producing the symptoms.

[ED. NOTE.—While it is undoubtedly true that in some cases pain in the back is due to a combined lesion of both sacro-iliac joints or of the lumbosacral and one sacro-iliac joint, nevertheless, one of the lesions is usually primary and the other secondary. The secondary lesion will usually clear up with the disappearance of the primary lesion. We should endeavor to improve diagnostic methods in order to differentiate the cause of the back pain rather than to rush in and perform a "gun-shot" type of operation devised with the idea of making up by number of shots for lack of proper aim. This is not to say, however, that the operation of trisacral fusion may not prove to be a valuable procedure under certain conditions when tested by further experience. It is difficult to see how injury to the posterior sacral plexus can be avoided.]

Extra-Articular Fusion of the Hip.—Albee [45] considered that the indications for extra-articular fusion in tuberculous hip disease were: (1) constant relapse of the adduction deformity in spite of proper conservative treatment; (2) recurrence of the adduction deformity following correction by osteotomy; (3) marked destruction of the head of the femur and acetabulum; (4) evidence of recurrence of activity of the disease process, and (5) active tuberculous hip disease in an adult even though the amount of destruction of bone was slight.

He considered it advisable for the surgeon to have at his disposal more than one method of extra-articular fusion in order to meet the individual indications. He described three operative methods that he had employed. He preferred the massive bone graft carefully fitted and mortised to "chip grafts" and the transplantation of the trochanter. He reported thirty-one operative case, details of which were given in eight.

After describing the technic of an operation for extra-articular fusion of the hip in tuberculous disease which resembled the method of Hibbs but was described by the author in 1922, Hass [46] stated that in his opinion the operation was indicated only in adults and then only when the patients were in good general condition and the disease process was in a quiescent stage. He did not agree with Hibbs, who advocated the operation in children even below the age of 10 years. He had performed the operation only in four patients.

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45. Albee, F. H.: Ann. Surg. **89**:404 (March) 1929.

46. Hass, J.: Ztschr. f. orthop. Chir. **51**:495, 1929.

Schumm [47] employed an operation for fusion of the hip with what he called an iliotrochanteric strut graft, the graft being taken from the femur and placed in such a manner as to bridge the space between the ilium and the trochanter. He had performed the operation in nine patients with uniformly successful results.

[ED. NOTE.—The editors would like to make a plea for greater accuracy in the use of the term "extra-articular" in relation to fusion operations of the hip. The difference between intra-articular and extra-articular methods is more relative than absolute, and there are few of the so-called extra-articular methods that do not open the joint at least occasionally.]

Late Results of Resection of the Semilunar Cartilage of the Knee.—Tavernier and Chappoux,[48] who advocated under certain conditions complete resection of the internal meniscus by medial transverse arthrotomy with division and resuture of the internal lateral ligament, reported the end-results in fifteen patients treated by this method. All the patients were football players, and it was found that thirteen had resumed play after an interval varying from two to twelve months, with an average of five months. Of these, eleven had perfect knees, one showed a little limitation of motion and another a slight decrease of strength. Two had not returned to football playing; of these, one had a perfect knee and one showed slight increase of lateral mobility. Both of these patients, however, had sustained rupture of the anterior crucial ligament.

[ED. NOTE.—The operation of transverse arthrotomy with division of the internal lateral ligament reported by the authors seems totally lacking in merit and deserves the strongest condemnation. Even if complete excision of the cartilage were required, which is rarely the case, this could be done readily through the combined anterior and posterior incisions described by Henderson.]

Synovectomy in Chronic Arthritis.—Allison and Coonse [49] examined the patients at the Massachusetts General Hospital on whom synovectomy had been performed. They considered the procedure particularly valuable in the proliferative type of arthritis; twenty-seven of the fifty patients studied had this condition. They advised against synovectomy in pyogenic or gonorrheal arthritis, unless perhaps in the chronic stage. In 95 per cent of the cases pain was almost entirely relieved, and the patients retained nearly as much motion as before operation. The authors also advocated the operation of synovectomy in other joints than the knee under proper conditions.

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47. Schumm, H. C.: Surg. Gynec. Obst. **48**:112 (Jan.) 1929.

48. Tavernier and Chappoux: Presse méd. **37**:179 (Feb. 6) 1929.

49. Allison, N., and Coonse, G. K.: Synovectomy in Chronic Arthritis, Arch. Surg. **18**:824 (March) 1929.

[ED. NOTE.—The editors are less optimistic than the authors about the results of synovectomy. They urge the necessity of a careful selection of cases for the operation.]

Posterior Capsuloplasty in Certain Flexion Contractures of the Knee.—After reviewing the operations of Murphy, Putti, Smith and Silver for correction of deformities of knee flexion, Wilson [50] described the operation of subperiosteal posterior capsuloplasty of the knee together with the postoperative treatment. The operation consisted in exposing the lower end of the femur through a lateral incision in front of the biceps tendon, which was divided by a Z-shaped tenotomy. The iliotibial band was sectioned transversely and the capsule was stripped subperiosteally from the posterior aspects of the femoral condyles, particular emphasis being placed on thorough stripping of the intercondyloid notch. It might be necessary to make a second incision on the inner side of the femur to obtain complete stripping mesially. After the capsule was freed, the knee was manipulated into complete extension, care being exercised not to injure the external popliteal nerve. A split plaster cylinder was then applied to be worn one week. Exercises and massage were started in one week, and weight-bearing with a brace was allowed in eight weeks. The operation had been performed twenty-one times in fifteen patients. The flexion contracture was due to chronic arthritis in thirteen patients and of traumatic origin in the remaining two.

Lengthening of the Leg.—Carrell [51] reviewed the results in twenty-eight patients on whom he had performed the operation of leg lengthening described by Abbott. In twenty-one patients the tibia and fibula were lengthened, in seven the femur. Following the tibial operations, complications occurred in four cases. In one case distraction of the bones was delayed until the tenth day, when sufficient union had occurred to prevent extension. The second complication was caused by placing the upper pin too near the epiphyseal line so that it gave way when pressure was applied. In a third case the fibula was not entirely divided and the external malleolus was dislocated upward. In the fourth case, a severe hemorrhage from the pin holes presumably due to injury of the posterior tibial vein resulted on two occasions when attempts were made to apply extension and the lengthening was abandoned. The author did not consider the operation difficult or unusually shocking, but it was necessary to observe meticulous care both in the technic of the operation and during the long after-care.

Treatment for Pes Cavus.—In discussing Scherb's technic for the treatment for pes cavus, Pick [52] stated that it consisted in the trans-

50. Wilson, P. D.: J. Bone & Joint Surg. **11**:40 (Jan.) 1929.
51. Carrell, W. B.: South. M. J. **22**:216 (March) 1929.
52. Pick, H.: Zentralbl. f. Chir. **56**:1876, 1929.

plantation of the long extensor tendons of the toes into the metatarsals together with forcible manipulation of the foot by means of Schultze's osteoclast or resection of portions of the os calcis, cuboid and scaphoid. The transplantation of the tendons was alone sufficient in feet that were easily correctible without force. The operation had been performed at the Dortmund Orthopaedic Clinic in thirty-eight patients, and end-results had been obtained in thirty-four of these. The results were good in all cases, in some excellent. The anterior arch showed considerable improvement, and lowering of the longitudinal arch was obtained in all the cases. He advised in the average case transplantation of the tendon of the extensor longus hallucis into the first metatarsal, of the tendons of the long extensors of the second and third toes into the second metatarsal and the tendons of the third and fourth toes into the fourth metatarsal.

Subastragalar Arthrodesis.—MacAusland [53] described his technic of subastragalar arthrodesis and reported eight cases in which it had been performed. He considered the operation useful in imbalance due to paralysis and in joint fractures or joint disease. He employed a semicircular incision, beginning on the dorsum of the foot at the astragaloscaphoid joint, curving under the external malleolus and terminating over the Achilles tendon. By forcibly inverting the foot, it was possible to dislocate the subastragalar joint and obtain complete exposure. With a hand saw generous portions were removed from the under surface of the astragalus, the superior surface of the os calcis and from the scaphoid and midtarsal regions. This permitted considerable backward displacement of the foot, the most important advantage of the operation.

[ED. NOTE.—The operation of subastragalar arthrodesis as it is usually performed is so simple and gives such satisfactory results that considerable evidence will have to be presented before we shall be convinced that wide dislocation of the joint as advised by the author is of sufficient advantage to counterbalance the additional trauma which it must cause to the soft parts.]

FRACTURES

Fractures from the Operative Point of View.—In discussing the open treatment for fractures, Henderson [54] pointed out the dangers of the method when employed improperly. He listed the fractures of the lower extremity most satisfactorily treated by the operative method as follows: (1) fractures of the astragalus with marked displacement, (2)

53. MacAusland, W. R.: Subastragalar Arthrodesis, Arch. Surg. **18**:624 (Feb.) 1929.

54. Henderson, M. S.: Radiology **12**:214 (March) 1929.

Pott's fracture with the internal malleolus broken off at a high level, (3) refractory fractures of the ankle, (4) spiral oblique fractures of the lower third of the tibia, (5) fractures of the patella, (6) most fractures of the shaft of the femur in adults, (7) fracture dislocations of the hip, (8) slipped epiphysis of the upper end of the femur in children. Of the injuries of the upper extremity, he considered that the following often required operative intervention: (1) overriding fractures of the metacarpals, (2) badly comminuted fractures of the scaphoid, (3) fractures of both bones of the forearm, (4) most fractures of the lower third of the radius other than Colle's fractures, (5) most fractures of the head of the radius, (6) fractures of the olecranon process, (7) epiphyseal separation at the lower end of the humerus with anterior displacement of the lower fragment, (8) fractures of the surgical neck of the humerus with overriding, (9) fracture dislocations of the head of the humerus.

Closure of Compound Fractures by Skin Plastic.—Cannaday [55] advocated the closure of compound fracture wounds by skin plastic rather than to leave the wound open with the bone exposed, which under the most favorable circumstances resulted in extensive scar formation at the fracture site. The simplest method was to do débridement, make linear incisions on either side of the fracture and free the skin sufficiently so that the edges could be approximated over the fracture.

[ED. NOTE.—We agree with the author as to the advisability of covering exposed bone with skin, provided free drainage can be instituted from the sides.]

Fractures of the Clavicle.—From a review of the treatment of 422 patients of both sexes, adults and children, with fractured clavicles, Lester [56] concluded that with any type of ambulatory treatment the functional results were uniformly good. He advised a simple comfortable dressing (sling, swathe or binder), rather than intricate apparatus designed to hold the fragments in place.

Fractures of the Lateral Humeral Epicondyle in Children.—After a review of 160 case records and a study of sixty children between the ages of 4 and 8 years with fractures of the external condyle, Massart and Cabouat [57] separated these injuries into three classes: (*A*) fractures and epiphyseal separations without displacement; (*B*) fractures with outward displacement with or without tilting of the fragment, the displacement being limited by the capsuloperiosteal attachments; (*C*) fractures where the fragment has broken loose from its attachments and gross displacement has taken place.

55. Cannaday, J. E.: Ann. Surg. **89**:579 (April) 1929.
56. Lester, C. W.: Ann. Surg. **89**:600 (April) 1929.
57. Massart, R., and Cabouat: Rev. d'orthop. **15**:475 (Nov.) 1928.

In group *A* there were fifty-one cases of subperiosteal fracture or epiphyseal separation without displacement, and all yielded excellent results.

In group *B* there were forty cases with outward displacement, but without tilting, and nineteen cases with tilting. Of the latter, thirteen patients obtained perfect results, four showed some deviation of the carrying angle and two had considerable limitation of motion.

In group *C* the results of conservative treatment were poor. The fragment was separated from its ligamentous attachments and deprived of blood supply, resulting in necrosis of the epiphyseal cartilage of the condyle and arrest of growth. This factor was more important in accounting for the poor prognosis than the extent of the displacement. Increasing cubitus valgus developed as a result of the cessation of growth of the outer half of the condylar portion of the humerus, and in time was likely to cause a delayed ulnar palsy. The poor results in this group of fractures would seem to point to the advisability of early operative intervention with replacement and suture of the loose fragment.

Injuries of the Lower End of the Radius.—Edwards and Clayton [58] examined, two years after injury, the late results of 424 fractures of the lower end of the radius, 339 of which were of the Colles type. In 73 per cent there was no disability; 23 per cent complained of minor aches, but were able to carry out their normal occupations, and of these a third had arthritis of the wrist before the injury. In 4 per cent the results were bad. Persistent tenderness over the internal lateral ligament was common, but usually disappeared under physical therapy. Full rotation was usually regained after the patient had returned to work. Many of those in whom limitation of rotation persisted were cured by a manipulation of the forearm under nitrous oxide anesthesia. The poor results were attributed by the authors to: (1) a preexisting arthritis of the wrist joint and (2) failure to reduce the backward tilt of the lower radial fragment.

Grasby and Trick [59] also reviewed the results of fifty Colles' fractures two years after the injury. They concluded that a good result invariably followed a good reduction, and that if displacement persisted the result was almost as invariably unsatisfactory on account of a traumatic arthritis of the radio-ulnar joint. Nonunion of the styloid of the ulna did not affect the functional result.

Thurston Holland [60] drew attention to the fact that a genuine epiphyseal fracture of the lower end of the radius, that is, one in which

58. Edwards, H., and Clayton, E. B.: Brit. M. J. **1**:61 (Jan. 12) 1929.

59. Grasby, E. D., and Trick, S. R.: Brit. M. J. **1**:391 (March 2) 1929.

60. Holland, C. T.: Proc. Roy. Soc. Med. **22**:23 (March) 1929.

the fracture was exclusively in the line between the cartilage and the diaphysis without any injury to the latter, was rare. In practically every case there was some diaphyseal injury as well, and this was seen in the lateral roentgenograms as a small wedge of bone torn off from the edge of the diaphysis. This enabled a diagnosis of "separated epiphysis" to be made by roentgenography even when the displacement had been reduced.

[Ed. Note.—This also accounts for the fact that arrest of growth following separation of the lower epiphysis of the radius is rare.]

Fractures of the Transverse Processes.—Hartwell [61] reported the results of a study of twenty patients with isolated fractures of the transverse processes of the lumbar vertebrae. The processes of the third and fourth lumbar vertebrae were involved most frequently. Healing was usually by fibrous union. One third of the patients were discharged from treatment in six weeks, free from pain. The other patients continued to have pain, one for a period of more than three years. Five of the patients were submitted to operation, and the transverse processes were removed. In these the duration of the disability averaged less than six weeks, with complete cure in all cases. He considered the group too small to justify more than tentative conclusions.

[Ed. Note.—We should like to see the report of the results in a larger series of patients before advocating excision of these fractured transverse processes.]

Compression Fractures of the Spine.—Davis [62] considered that the treatment for compression fractures of the spine should aim at correction of the kyphotic deformity and securing proper alinement just as much as reduction was sought in fractures elsewhere He had been able to obtain this by actively hyperextending the patient on a Bradford frame or plaster shell, or when the posterior spinal arch was intact, by careful manipulative treatment, forcing the spine into hyperextension followed by the application of anterior and posterior plaster shells. A roll in the form of a life preserver was attached to the posterior shell under the point of the kyphos. The patient was kept in the plaster shell for seven weeks, after which a Taylor back brace was applied to be worn in bed for two weeks followed by gradually increasing weight bearing. He reported cases in which the manipulative method had been successfully used, including four cases of fracture dislocation with involvement of the cord. The entire group on which the report was based comprised twenty-nine patients.

[Ed. Note.—Davis has made an important contribution in advocating an active policy with regard to the correction of bony deformity in spinal fractures. In his hands the manipulative method has yielded

61. Hartwell, J. B.: Colorado Med. **26**:37 (Feb.) 1929.
62. Davis, A. G.: J. Bone & Joint Surg. **11**:133 (Jan.) 1929.

good results; whether or not it is free from dangers will have to be demonstrated by further experience. We shall be interested to compare the results of this method with those obtained by Rogers, who used a method of gradually increasing hyperextension on a special hyperextension frame, which is soon to be reported.]

Kümmell's Disease.—Wier [63] encountered eight cases of Kümmell's disease, the symptoms developing from a few months to a year after a severe injury to the back. He deprecated the too great dependence on a single negative roentgen examination, following which the patient received no treatment until spinal deformity and the typical nerve root symptoms developed. In the way of treatment, he advised fixation of the hyperextended spine in a plaster jacket applied in such a way that the weight of the shoulders was borne on the pelvis and the load removed from the vertebrae.

Fractures of the Shaft of the Femur.—Campbell [64] treated patients with fractures of the shaft of the femur by manual reduction followed by immobilization in a plaster of paris spica casing, and after a large experience believes that it was the most reliable method of treatment. He employed an orthopedic fracture table equipped with apparatus for roentgen examination. Under full anesthesia the fragments were reduced by traction and angulation, the ends being made to impinge and interlock, and the position controlled by immediate roentgen examination. A double plaster spica was then applied with the hip and knee flexed.

He deprecated repeated manipulations. The most difficult type of fracture to treat was the oblique, with fairly smooth bone ends. The prolonged immobilization did not cause permanent limitation of motion of the knee. He tabulated the end-results in a group of seventy-one patients whom he had treated, and considered them as satisfactory as those obtained after any other method of treatment. In nineteen patients there was a shortening of ½ inch (1.27 cm.) or more, and in five, of 1 inch (2.5 cm.) or more. In only five of the cases was a second manipulation necessary.

[Ed. Note.—There are several ways of treating almost any fracture, but it does not follow that every one can duplicate the results of some one else, a certain method being used. Campbell is able to obtain good results with fractures of the femur by the manipulative method, but we doubt if this is as safe or reliable a method in the hands of the average surgeon as the traction method of treatment. It must be particularly difficult to hold the comminuted and oblique fractures in proper alinement in a plaster casing.]

63. Wier, S. T.: Texas State J. Med. **24**:699 (Feb.) 1929.
64. Campbell, W. C.: Radiology **12**:106 (Feb.) 1929.

Fractures of the Lateral Tuberosity of the Tibia.—Cubbins, Conley and Seiffert [65] called attention to the increasing frequency of fractures of the lateral tuberosity of the tibia which they thought might well be designated "bumper" fractures owing to the fact that they so commonly resulted from collision with an automobile bumper. Forcible abduction of the tibia on the femur was the common mechanism. Improper treatment resulted in a loose joint with genu valgum and permanent disability. If the tuberosity was widely separated, it might be reduced manually or with the aid of a mallet. If the fragments could not be replaced, an open operation should be performed. They had found by arthrotomy that in some of these cases the lateral meniscus was torn loose and its outer rim was displaced down between the fragments, where it prevented reduction. The authors considered it a mistake to remove the meniscus, as its broad cartilaginous surface would surely help to render the joint more stable in case of resulting irregularity of the upper joint surface of the tibia. Replacement of the cartilage was the better treatment.

Astragalectomy for Fracture of the Astragalus.—Graham and Faulkner [66] advocated astragalectomy in fractures involving the body of the astragalus with displacement when it was impossible to reduce the fragments. They believed that a stable painless ankle with from 20 to 25 degrees of motion could be obtained by the operation, and that this was to be preferred to the stiff and painful ankle which commonly resulted without astragalectomy. They had followed up ten patients on whom astragalectomy had been performed. Of these, eight had severe fractures of the body of the astragalus, and only three were seen for the first time within one month of the injury, the rest being late cases. Five of the ten patients had painless, stable feet, and had returned to their former occupations; two had fair results, and three had definitely poor results.

DISLOCATIONS

Anterior Dislocation of the Elbow.—Anterior dislocation of the elbow, according to Tees and McKim,[67] was a rare type of injury, only thirty-one cases having been reported in the literature, and only twenty-three of these being true anterior dislocations of both bones. They had seen two patients with this condition, both being children. In one, the injury followed a blow on the flexed elbow; in the other, the forearm was caught and pulled in the belt of a cement mixer. Both dislocations were reduced by manipulation without difficulty, and the recovery was complete in both cases.

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65. Cubbins, W. R.; Conley, A. H., and Seiffert, G. S.: Surg. Gynec. Obst. **48**:106 (Jan.) 1929.

66. Graham, W. T., and Faulkner, D. M.: Ann. Surg. **89**:435 (March) 1929.

67. Tees, F. J., and McKim, L. H.: Canad. M. A. J. **20**:36 (Jan.) 1929.

Costovertebral Luxation.—Stewart and Warren [68] were able to find records of only ten cases of costovertebral luxation in the literature. They had treated a patient in whom the first rib was dislocated downward following a severe injury. Anesthesia was present around the inner condyle of the humerus and along the ulnar surface of the forearm and over the ring and the little finger. The dislocation was reduced by operation, which showed the head of the rib displacing the lower portion of the brachial plexus. The sensory disturbance disappeared immediately after operation.

RESEARCH WORK

Viability of Transplanted Bone.—Pollock, McKenney and Blaisdell [69] transplanted bone with periosteum into the knee joint, abdominal cavity and muscles of dogs, and studied the effect on the transplant. Two inch (5 cm.) pieces of rib fractured transversely were used as transplants. Some were transplanted as such; others were enclosed in collodion membranes. In the latter, death of the transplant invariably occurred because the membrane prevented ingrowth of new blood vessels. New bone formation occurred only when the transplant itself became well surrounded by fibrous tissue well supplied with blood vessels. The transplants seemed to survive best when transplanted in muscle. New bone formation in the abdominal cavity took place in only one instance, while all the transplants into the knee joint died.

Effect of Bone Transplantation on the Blood Calcium Level.—Halperin and Walsh [70] attempted to duplicate the work of Schmidt and Obrastzow of Leningrad, who stated that they were able to raise the blood calcium level by homogeneous and heterogenous bone grafts. The Russians transplanted the graft to the pectoral region between the skin and fascia in six persons. In those with the homogeneous graft, there was a 9 per cent rise in the blood calcium, while in those with the heterogenous graft there was a 4 per cent raise. They believed that the graft acted not only as a depot of calcium, but also as a foreign body in response to which calcium ions were absorbed into the circulation.

Halperin and Walsh, however, experimenting with rabbits and dogs, were unable to reproduce these results. They used three normal dogs and three normal rabbits, and made weekly observations on the blood calcium for four weeks. They found no appreciable changes and con-

68. Stewart, S. F., and Warren, J. W.: Luxation of the Costovertebral Joints, J. A. M. A. **92**:605 (Feb. 23) 1929.

69. Pollock, W. E.; McKenney, P. W., and Blaisdell, F. E.: Viability of Transplanted Bone: Experimental Study, Arch. Surg. **18**:607 (Feb.) 1929.

70. Halperin, G., and Walsh, E. L.: The Effect of Bone Transplantation on the Blood Calcium Level, Arch. Surg. **18**:819 (March) 1929.

cluded that the changes observed by Schmidt and Obrastzow were within normal limits.

They admitted however, that their animals were not in a state of hypocalcemia and that possibly a bone transplant might elevate the calcium level in such a condition.

Effect of the Thymus on the Consolidation of Fractures.—Glässner and Hass [71] studied the healing of fractures and the influence on the rapidity of healing of thymic extract. Employing cats for their experiments, they extirpated the thymus and produced fractures of uniform type. One half of the animals operated on was given daily injections of thymic extract for a period of fourteen days, while the other half was used as a control. The progress of healing was followed by roentgen examination every eight days, and at the end of four weeks the animals were killed and the specimens of bone were obtained. The animals that had not received thymic extract showed a much more feeble callous than normal, while the animals that had received thymic extract showed complete consolidation. In a second series of experiments they compared the effect of other glandular extracts with that of the thymus, but the latter always exhibited the greatest effect in hastening the healing of the fracture.

Importance of Vessels in the Round Ligament to the Head of the Femur.—Zemansky and Lippmann,[72] in a series of rabbits 2 weeks old, sectioned the ligamentum teres on one side, thereby obliterating the circulation through it to the femoral head in order to determine the effect of this procedure on the developing capital nucleus. The specimens were examined from six to thirty-six days later. The changes observed in the femoral heads were anemia, necrosis, signs of cessation of ossification in this area, gross deformation of the femoral head and coxa vara.

They concluded that the vessels of the round ligament were essential, at least in rabbits, for the normal development of the femoral head. Furthermore, as adolescence progressed, the importance of these vessels gradually diminished, until the epiphysis united with the shaft, at which time in normal animals the nutrition was derived entirely from below. They thought it reasonable to suppose that similar conditions prevailed in human beings at the same relative period, i.e., the period during which coxa plana or osteochrondritis juvenalis appeared. If this supposition was correct, it was not unlikely that the cause of the disease was to be found in some maladjustment of the delicate physiologic balance that existed between these sources of nutrition to the femoral head.

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71. Glässner, K., and Hass, J.: Presse méd. **37**:176 (Feb. 6) 1928.

72. Zemansky, A. P., Jr., and Lippmann, R. K.: Surg. Gynec. Obst. **48**:461 (April) 1929.

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